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THE OBSCURATION OF VISION THROUGH DAYTIME TELESCOPES BY EXTERNA--ETC(U)

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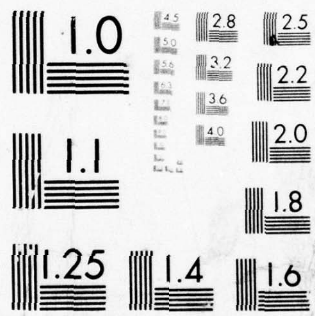
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Technical Memorandum 24-78

THE OBSCURATION OF VISION THROUGH DAYTIME TELESCOPES BY EXTERNAL COATINGS: FIELD TEST RESULTS

Christopher C. Smyth

August 1978
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U. S. ARMY HUMAN ENGINEERING LABORATORY

Aberdeen Proving Ground, Maryland

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The effectiveness of external coatings for obscuring vision through daytime telescopes was determined for four coating materials and three levels of area coverage. In a field test, subjects searched through a main gunner's telescopic sight for panel targets emplaced on an outdoor range. Glass slides were placed in front of the objective lens to obscure vision. The slides had been coated with one of the four materials in one of three predetermined random patterns. The test showed that the material ranking in order of decreasing effectiveness is (1) green dye, (2) carbon black, (3) clear silicone base, and (4) aluminum pigment. The green dye was effective at 100 percent and 80 percent coverage, but ineffective at 30 percent. The carbon black was only effective at 100 percent coverage.

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THE OBSCURATION OF VISION THROUGH DAYTIME TELESCOPES BY EXTERNAL COATINGS: FIELD TEST RESULTS

INTRODUCTION

An aerosol spray for use as a non-lethal countermeasure against armored vehicles is under development by the US Army Mobility Equipment Research and Development Command (USAMERADCOM), Special Projects Office, Barriers Division. The spray will contain finely divided "sticky" particles which tend to adhere to, and collect on, externally exposed optical surfaces. The particles will be hard to remove and will interfere with the normal functioning of optical devices.

One application considered is against the main gunner's telescopic sight on an armored vehicle. The aerosol would be released within the proximity of the armored vehicle to coat the exterior surface of the objective lens of the main gunner's sight. Since the telescope is in an awkward location to reach from within the vehicle, the coating would be difficult to remove without vehicle downtime. USAMERADCOM is particularly interested in the use of silicone-base materials because of their affinity for glass.

USAMERADCOM requested that the US Army Human Engineering Laboratory (HEL) conduct experiments to determine the relationship between the probability of a round hitting a target and aerosol coating parameters. The round would be fired by a gunner sighting through a main gunner's telescopic sight following application of the aerosol coating. In support of this effort, HEL separated the work into a preliminary investigation phase to be followed by a field test.

During the preliminary phase, HEL investigated the effects of various coating materials upon the visibility of panel targets which had been emplaced on an outdoor range. The targets were viewed by a single observer using the optics from a M20A3 periscope and coated glass slides. This early phase of the study resulted in a computer model for obscured optics.[1] The model includes the effects of sky irradiance, sun angle, atmospheric attenuation, target and background radiance, scope coating and color differences upon the visibility of the target. USAMERADCOM requested that HEL test the validity of the computer model.

The field test determined the effectiveness of four coating materials and three levels of area coverage in obscuring vision through a main gunner's sight. Subjects in the field test searched through the sight for panel targets which had been emplaced on an outdoor range. Glass slides were placed in front of the objective lens to obscure vision. The slides had been coated with one of four materials in one of three predetermined random patterns.

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[1] Smyth, C. C. Obscuration By External Coatings of Vision Through Daytime Telescopes: A Preliminary Investigation. Technical Memorandum 27-76, US Army Human Engineering Laboratory, Aberdeen Proving Ground, MD, August 1976.

This report describes the method, apparatus, subjects, and procedures employed in the field test. The test results are statistically analyzed and discussed. During the test, certain measurements of test conditions were recorded. These include lighting conditions, target and background spectra-reflectance valves, coating parameters and the visual acuities of the subjects. This data along with the recording apparatus and procedures will be presented in a subsequent report devoted to computer model verification.

METHOD

Subjects searched through a telescopic sight for three panel targets placed on an outdoor range 500 meters long by 60 degrees wide. The sight was a main gunner's articulated telescope used in foreign armored vehicles, and was mounted in an expandable shop van located at the apex of the range sector. Coated glass slides were placed in front of telescopic objective lens. The number of targets detected and identified was recorded along with the detection times and centering coordinates for each glass slide. The targets were relocated on the test range once every test cycle. Each subject looked through only one slide during all test cycles. The tests were conducted during late October and early November 1976.

The glass slides had been spray-coated with one of four different materials: (1) green dye, (2) lampblack in oil, (3) aluminum particles, or (4) clear base. All materials were in a silicone base. The slides obscured 100 percent, 80 percent, or 30 percent of the field of view. The coating had been applied with an air-brush gun in equal amounts equivalent to a 30 percent darklight tone for the lampblack. Masks cut in a random pattern were used to insure consistent area coverage.

Twenty-two subjects were tested in fixed-factor format without repeated measures on the slides. The test was separated into two consecutive phases. The first phase compared the four materials at 100 percent area coverage in a four-level, single-factor experiment. Four subjects were tested on three of the levels and two on the fourth. The second phase tested the two most effective materials, as determined from the first phase, at the two additional levels of 30 percent and 80 percent area coverage. Two subjects were tested per level in this 2x2 factorial experiment. Subjects were assigned to a test level according to their Orthorater readings, so that the average readings for all levels were approximately equal.

Measurements were made of pertinent test conditions. The apparatus, measuring techniques and recorded data will be listed in a subsequent report. (See Appendix B for the Orthorater readings of the subjects.) The outdoor lighting conditions measured intermittently during the test include measurements of the sun angles, cloud cover, sky irradiance, sky illuminance, horizontal sky luminance and atmospheric attenuation. The internal van illuminance levels were also recorded. The spectra reflectance values for the target and viewing background were recorded at a later date. Finally, the spectra transmittance and scattering coefficients for the four materials were measured later.

TEST RANGE

The test range was emplaced on an open grass field, 400 meters wide by 300 meters long, located in the Wirsing Test Area (Swamp Quarter) on Aberdeen Proving Ground (APG), MD. The grass field lies just beyond the safety zone of the south end of the 8000-foot runway (22-04)at the USA Phillips Airfield. The field is bisected by a creek and a rarely used access road, and is surrounded on three sides by a tree-line. (See Figure 1 for a sketch of the test site and range.)

The test range was in the form of a sector 500 meters long and 60 degrees wide. The apex of the range was located in the eastern corner of the field and the centerline was erected in a east-west direction (296 degrees) away from the airport. Thirty target positions were emplaced on the test range. The range was separated into three consecutive sections. Each section extended 133.3 meters along the centerline, starting from the 100-meter mark. Ten target positions were assigned to each section by random selection of both the range along the centerline and the azimuth about it. Adjustments were made in the field during emplacement to insure that all targets positions were clearly visible from the nominal eye-level at the range apex. Table 1A lists the coordinates of each target position measured by the centerline distance from the apex and the angular separation from the centerline.

APPARATUS

The apparatus described in this section are the equipment and materials used to test the subjects.

1. Main Gunner's Telescopic Sight—An articulated telescope, main gunner, Model TSH-S-41(U) was used to test subjects. (See Table 1 for a partial list of characteristics for the telescope.) The wiper blade for the objective lens was removed and a slide holder mounted in its place in front of the objective lens. The front of the telescopic housing and the entire slide holder was painted with flat black paint. The visual path between the objective lens and the slide holder was further protected by a rubber sleeve inserted between the housing and the holder. These precautions were taken to prevent ambient light from reflecting off the back of the glass slides into the telescope.

The telescope was mounted on a support with free movement in both elevation and azimuth. The telescope could be aligned on the target and left in position without effort by the subject. The elevation and azimuth scales read in half-degree increments. The telescope has two levels of magnification, 3.5 for search and 7.0 for target identification. A focus ring is used to bring the reticle in focus with the target. Other accessories such as the internal reticle lighting (used in twilight) and the neutral density filter (used when viewing bright areas such as snowfields) were not employed during this test. The head rest was left in the right-eye viewing position at all times to preclude disturbance of the scale-range centerline alignment during testing.

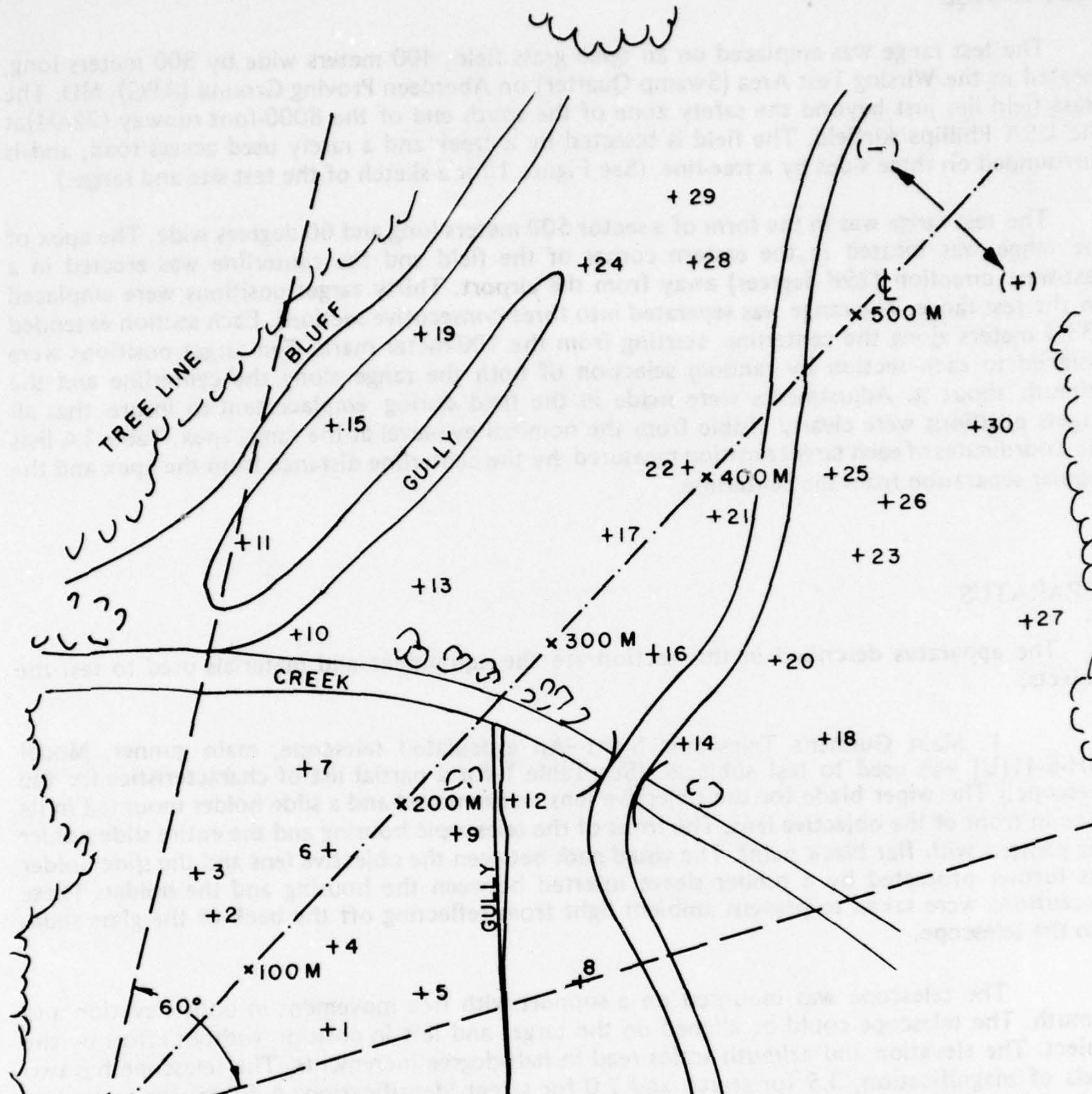


Figure 1. Test site.

TABLE 1

Characteristics of the Telescopic Sight

Characteristic	Magnification Low (3.5x)	High (7.0x)
Field of view (mils)	300	150
Entrance pupil diameter (mm)	19.3	19.3
Exist pupil diameter (mm)	5.5	2.75
Light transmittance (%)	37.	35.
Resolution on axis (arc-secs)	13.	13.

The support with the telescope was mounted inside an expandable shop van which had been parked on blocks at the apex of the target range. A wooden panel with a viewing port (1 foot high by 2 feet wide) was placed at the rear exit to control the ambient light within the van. The telescope was directed down range through the viewport at the rear of the van. A black sheen cloth, hung from the ceiling between the subject's viewing position and the viewport, was taped about the telescope at the support pivot point. The cloth blocked sky light from the viewport and further insured control of the ambient light within the van.

A space was provided between the sheen drop cloth and the wooden panel for the front of the telescope with the objective lens and the attached slide holder. The slide holder was nearly flush (within 2 inches) with the viewport, and the outside wall of the panel was painted with flat black paint to reduce stray light reflections.

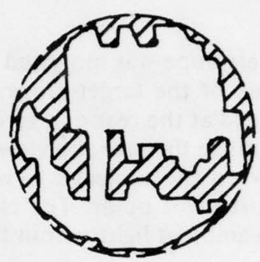
The shop van was partitioned into a subject testing area containing the telescope support, a subject holding area and an instrument work bench. The test area was physically isolated from the other two by the partitioning panels. A barrier was erected along side the van to prevent subjects from viewing down the range during outside rest breaks.

2. Panel Targets—Three wooden panel targets were used in this test. Each panel target was constructed in one of three compact shapes: circular, square and equilateral triangle. Each panel had a cross-sectional area of 9 square feet. The panels were painted with semigloss olive drab (Federal Std 595, No. 34087). Stands were built to hold the panel targets at a height 2 feet above the ground. The stands were painted in wavy stripes of olive drab and black paint to insure inconspicuity. When emplaced, each target stood roughly 5 feet from the top to ground.

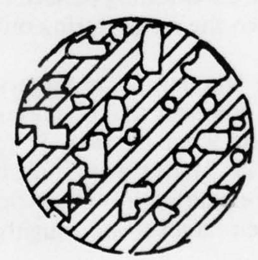
3. Coated Glass Slides—The coated glass slides, inserted into the slide holder to obscure telescoptic vision, were prepared by spraying glass slides (1.92 inches x 1.92 inches x .02 inches) with material pigments mixed in a silicone base. The pigments were (1) green dye, (2) lampblack, (3) aluminum flakes, or (4) clear base. The coating base was prepared from dimethyl silicone fluid (General Electri Viscosil 500,000) mixed with the solvent xylene in a 1 to 10 ratio by volume. The pigmented mixtures were prepared by adding aluminum flakes (Alcoa 1594, non-leafing), lampblack pigments in oil (color ID), or a green dye to the base in a 1 to 11 ratio by volume. The green dye was prepared by using equal proportions of green fluorescent paint, Palmer Paint Products, Inc., and L-400 Clear Frost, Cryst-L-Craze, Fry Plastics International, Inc.

Each mixture was sprayed from an air brush gun (nomenclature: Wren Model A air brush gun, Binks Manufacturing Co.) in a fine mist spray onto a glass slide. The spraying parameters were held constant for each slide (fine spray, 3 inches between slide and gun head, 2 seconds per pass and 30 passes per slide). The coating for the lampblack mixture was judged equivalent to a 30 percent light-dark tone. Masks were used to produce the 30 percent area coverage and 80 percent coverage. Slides were provided with handling tabs to insure proper orientation during insertion.

The coating masks were constructed from random number selections of the appropriate number of grid segments of a 1/10-inch x 1/10-inch grid fitted to the 1¼-inch diameter objective lens. The 80 percent area mask is quasi-random since several grid points were interchanged to provide continuity necessary for mask construction. Figure 2 shows the mask configurations used on the 30 percent area coverage and 80 percent area coverage.



(A) 80 % AREA COVERAGE



(B) 30% AREA COVERAGE

Figure 2. Masks used to prepare slides.

4. Orthorater—The distant visual acuity (both eyes and right eye) and color vision were measured for each subject using a modified Orthorater (Cat. No. 71-21-31-02, Bausch and Lomb, Inc., Rochester, NY 14062). Subjects who wore glasses for distant vision were measured and tested wearing their glasses.

SUBJECTS

Twenty-two subjects were employed in this test. Eighteen subjects were US Army enlisted personnel assigned to the Field Support Branch, Military Support Division, Material Test Directorate (MTD), APG, MD, for test purposes. Four subjects were USMC enlisted personnel assigned to the USA Ordnance School for training purposes. Nearly all subjects were young males in their late teens and early twenties with good distant visual acuity (some corrected with glasses) and color vision. Two subjects had slight color vision defects. Most had previous experience with telescopic sights either as tank gunners or in MTD tests of this nature. (See Table 1B in Appendix B for listing of subject information including age, rank, prior experience with telescopic sights, Orthorater readings for both distant acuity and color vision, as well as the coated slide assigned for testing. The table also includes information on four additional MTD subjects used in a pretest phase.)

PROCEDURE

The subjects were first tested with the Orthorater to determine their distant visual acuity (both eyes and right eye) and color vision. The results of the Orthorater test were used to assign the coated glass slides to the subjects. Assignments were made so as to ensure equal average distant visual acuity readings (right eye) for all slides.

Subjects were tested in groups of four. The morning session was spent in training. Subjects used the articulated telescope with an uncoated glass slide inserted into the slide holder. They were instructed to search for and identify each of the three panel targets emplaced on the range. They had to position the telescope so that the reticle was on the center of the target image. This procedure was repeated for all three targets in turn. Each subject completed three such training cycles and located a total of nine target positions. The three targets were moved to different range positions prior to each training cycle. Presumably, the training was stabilized within three cycles (Taylor, 1964).

The afternoon session was spent testing the subjects using the articulated telescope and the assigned coated slides. The test procedure was the same as the training procedure. Again, subjects were instructed to search for, identify, and position the reticle over each of the three panel targets in turn. However, each subject performed his visual task with the one slide assigned to him. Each subject completed three such test cycles and was presented with a total of nine target positions. As during training, the three targets were moved to different range positions prior to each test cycle.

Subjects were tested one at a time during the test cycle. Each was brought from one holding area and returned to another following completion of this test cycle. The subject was instructed to first adjust the telescopic focus while the telescope was swung to one side off-range. The slide assigned to the subject was then inserted into the slide holder and the telescope centered on a starting position (100-meter post on the range centerline). The telescope was set at low magnification and the time of day recorded. The subject was then instructed to locate and identify one of the panel targets. The time to detect the target and the identification made were recorded.

The telescope was then set to high magnification and the subject was instructed to verify his identification and center the telescopic reticle over the target image. The elevation and azimuth coordinates were recorded by the tester following centering. The tester then removed the slide to verify the sighting. The subject was not told the results of this check nor was he allowed to view the target without the slide in place.

The telescope was then reset to low magnification and the search, identification, and centering task repeated for the next panel target using the last target as starting position. The subject was allowed 60 seconds to search for the target. If he did not detect a target within this time period, the testing was discontinued for that test cycle.

The test cycle was repeated for all four subjects to complete a test run. At the end of a test run, the tester verified the location of each target by measuring the elevation and azimuth without a coated slide in the slide holder. The panel targets were then reemplaced on the range by test personnel in preparation for the next test run. Measurements of sky and atmospheric conditions were taken between test runs.

The assignment of target panels to range sector and sector-post positions for each test run was done in a random manner (i.e., random numbers) to ensure counterbalancing of extraneous variables (McGuigan, 1968). This was true also of the assignment of subjects to testing order within each test run. Each target panel was assigned to a range section in a random manner with the restriction that no more than one panel be in each section. Each panel was then assigned to a post position within the corresponding section, in a random manner with the restriction that no two targets be closer than 60 seconds in arc.

This was to preclude possible neural reinforcement of target images (Krisofferson, 1958). (See Table 2A in Appendix A for a list of target assignments to section and section-post position as a function of the training and test runs.)

All four subjects were given one test cycle in each test run. The testing order of the subjects in each test run was selected by random arrangement of the assigned subject numbers. The training and testing took a full day to complete and the subjects for each test day were assigned a subject number from one to four by random draw. (See Table 3A for testing order assignments as a function of training and test run.)

RESULTS

The data reduction, statistical analysis, and results are listed in this section. The training data was first analyzed to determine differences among the subjects assigned to the eight coated slides. The visual acuity data was analyzed in a single factor analysis of variance experiment with eight levels of coated slides. The detection times and centering errors were analyzed in separate 8x3 multifactor experiments with repeated measures on the three levels of training cycles. All targets were detected and correctly identified by all subjects during the training cycles. The visual acuity readings were assumed to be a valid measure of the subject's ability to perform detection and identification tasks under the more stringent test conditions.

The test phase data included measurements on the numbers of targets detected and the numbers identified, the detection times, centering errors, and the numbers of detection and identification errors. These were analyzed in separate analyses of variance. The data for the first test phase, comparing the four materials at full coverage, were analyzed in a 4x2 multifactor experiment with unequal cell frequencies and repeated measures on the training and test cycles.

The data for the second phase, comparing material and area, were analyzed in a 2x3x2 multifactor (unequal cell frequencies) with repeated measures on the training and test cycles. The Phase I data for the two materials at full coverage was combined with Phase II data for the two materials at partial coverage. The combining of data from different test phases for analysis purposes was assumed to be statistically correct in this case. Each subject was tested on only one slide. The tests were therefore not repeated measures on material or coverage. Furthermore, all subjects were tested by the same personnel with the same procedures during the same seasonal timeframe.

A computer program listed in Appendix C was used in the analyses. The program incorporates appropriate techniques (Winer, 599-603) for designs with unequal cell frequencies. The interactions proved to be significant in most cases and the simple main effects were analyzed separately (Winer, 529-532). The Newman-Kuels procedure was used to compare the mean value of significantly different main effects (Winer, 191, 528). A trend analysis was performed in some cases on such effects using orthogonal coefficients (Winger, 176). The Cockran's test was used to test the homogenity of variances where appropriate (Winer, 208, 527).

Data Reduction

The number of targets detected and the number correctly identified were reduced for each subject from the experimental data. A target was recorded as detected when the subject positioned the reticle pointer over the target image. A target was correctly identified when the subject stated the target shape following detection.

The sum of target detection times was also reduced for each subject, as were the centering errors and the numbers of detection and identification errors. A target detection time was measured from the time a subject was told to search for a target to the time he detected a target. A 61-second time period was recorded for those targets a subject failed to detect.

A centering error was defined as the square root of the sum of the squares of the difference between the angular coordinates of the sight following centering by the subject and those determined by the tester. Centering coordinates were only recorded for targets successfully detected by the subject. A 63.24 degree centering error was assumed for those targets a subject failed to detect, since this is the mean error for the telescopic field of movement.

An error in detection occurred when the subject confused a natural object (i.e., bush or tree) for a target. An identification error occurred when the subject stated the incorrect shape of a target successfully detected.

Training Data

The subjects were drawn from the available subject population without restriction. The tester had no control over the selection of the subjects, and in this sense the selection was a random sample. The subjects were categorized by their distant visual acuity readings (right eye); however, no subjects were rejected from the sample. The subjects were then assigned to the coated slides in a matched manner. The mean value of the visual acuity for the subjects assigned to each coated slide is approximately 10 as measured by the Orthorater. This value is equivalent to 20/20 vision on the Snellen scale, and is the mean value of the user's population.

An analysis of variance indicated no significant differences among the distant visual acuity (right eye) of the subjects assigned to the coated slides. (See Table 2 for a summary of the analysis of variance.) The Cochran's test shows the variance to be homogeneous. The Cochran test ratio of the largest variance to the sum of variance equals .3125 which does not exceed the critical value of .602 at the .05 level (one and 14 degrees of freedom).

TABLE 2

Summary of Analysis of Variance of the Visual Acuity Data

Source of Variance	SS	df	MS	F
Assigned slides	.0175	7	.0025	1
Experimental error	.3825	14	.0273	—
Total	.40	21		

An analysis of variance indicated no significant differences among the detection times for the training cycles. (See Table 3 for a summary of analysis of variance.) The Cochran's test showed that the variances for the subjects within groups is homogeneous; however, the test value for the variances of the cycles by subjects within groups, was slightly larger than the critical value indicating lack of homogeneity. Similar remarks apply to the training centering errors. (See Table 4 for a summary of analysis of variance.) In conclusion, there was little difference between the subject pools assigned to the coated slides in regard to visual acuity, detection times, and centering errors.

TABLE 3

Summary of Analysis of Variance for the Training Detection Times

Source of Variances	SS	df	MS	F
1. Between subjects				
a. Assigned slides	1488.37	7	212.62	2.41
Subjects within groups	1239.49	14	88.54	
2. Within subjects				
b. Training cycles	700.59	2	350.29	4.40
Interaction a x b	1043.03	14	74.50	0.94
b x subjects within groups	2224.96	28	79.46	

harmonic mean, n = 2.46

TABLE 4

Summary of Analysis of Variance for the Training Centering Errors

Source of Variances	SS	df	MS	F
1. Between subjects				
a. Assigned slides	22.69	7	10.38	.47
Subjects within groups	306.13	14	21.87	
2. Within subjects				
b. Training cycles	52.62	2	26.31	1.09
Interaction a x b	179.66	14	12.83	.53
b x subjects within groups	675.91	28	24.14	

harmonic mean, n = 2.46

Phase I, Materials

The analysis of variance for the number of targets detected is summarized in Table 5. The analysis shows significant differences among the materials, training, and testing phases, and the interactions. The simple main effects were analyzed and are summarized in Table 6. The materials are significantly different from each other during the test phase but not during the training. The test phase is significantly different from the training phase for the clear base, carbon black, and green dye materials. However, there is no difference between the training and test phase for the aluminum material implying that the material was no more effective than the uncoated slides used in training.

TABLE 5

Summary of Analysis of Variance for Phase I Number of Targets Detected

Source of Variance	SS	df	MS	F
1. Between subjects				
a. Materials	71.	3.	23.67	37.87*
Subjects within groups	6.25	10.	.625	
2. Within subjects				
b. Train/Test	160.	1.	160.	256.**
Interaction a x b	71.	3.	23.67	37.87*
b x subjects within groups	6.25	10.	.625	

harmonic mean, n=3.2

$*F_{.99}(3,10) = 13.1$

$**F_{.99}(1,10) = 20.$

TABLE 6

Tests on Simple Main Effects for Phase I Number of Targets Detected

Simple Main Effects	SS	df	MS	F
1. Materials by				
Test	129.	3.	43.	68.8*
Error within all	12.5	20.	.625	–
2. Train/Test by				
a. Aluminum (A)	0.4	1.	0.4	0.64
b. Clear base (C)	16.9	1.	16.9	27.04**
c. Carbon Black	84.1	1.	84.1	134.5**
d. Green Dye (G)	129.6	1.	129.6	207.3**
Errors within subjects	6.25	10.	.625	–

harmonic mean, n = 3.2 (Table 5)

*$F_{.99}(3, 20) = 9.88$

**$F_{.99}(1, 10) = 20.$

The means for the materials in the test phase were compared using the Newman-Keuls procedure. The results in Table 7 show that all materials were significantly different from each other. A trend analysis of the means for the materials in the test phase was conducted using orthogonal coefficients. The cell frequencies are unequal and the harmonic mean was used in this analysis. The orthogonal coefficients for the different trends do not satisfy the orthogonality conditions in this case. However, the analysis suggests that the trend is primarily a linear function for this choice of materials.

TABLE 7

Tests on Means for Materials by Test Effect Using Newman-Keuls Procedure for Phase I Number of Targets Detected

Materials	A	C	B	G
Ordered Means	8.5	5.75	17.5	0.
A	–	2.75*	6.75*	8.5*
C		–	4.0*	5.75*
B			–	1.75*
G				–

harmonic mean, n = 3.2 (Table 5)

$MS_{W.C.} = 0.625$ (Table 6)

*.05 level of significance for studentized range statistic, $g_{.95}(r, 20)$ where r is the number of steps separating means.

Inspection shows that the variances for the between-subjects error and the within-subjects error cannot be strictly homogeneous. Since no targets were detected with the green dye and all targets were detected with the uncoated slides, these slides were insensitive to the test conditions. The variances for these slides equal zero and the Hartley test or the Bartlett's test cannot be satisfied. However, the variances for the remaining slides are numerically small and the F-test is robust in cases of mild non-homogeneity.

TABLE 8

Trend of Means for Materials by Test Effect Using Orthogonal Coefficients for Phase I Number of Targets Detected

Material Mean Value	A 8.5	C 5.75	B 1.75	G 0.	c^2	C	D	SS	F
Linear	-3	-1	1	3	20	-94.4	64.	139.24	222.78*
Quadratic	1	-1	-1	1	4	3.2	12.8	0.8	1.28
Cubic	-1	3	-3	1	20	11.2	64.	1.96	3.14

harmonic mean, n = 3.2

$MS_{w.c.} = 0.625$ (Table 6)

$*F_{.99}(1, 20) = 16.2$

Similar remarks apply to the analysis of variance for the number of targets identified. The analysis, summarized in Table 9, shows significant differences among the materials, training and testing phases, and the interactions. An analysis of the simple main effects is summarized in Table 10. The means for the materials in the test phase are compared in Table 11. The results show that the aluminum material is not significantly different from the uncoated slide used in training. All materials are significantly different from each other in the test phase except the carbon black and the green dye. A trend analysis using orthogonal coefficients is summarized in Table 12. The analysis suggests that a quadratic function is appropriate for this selection of materials. Similar comments apply to the homogeneity of error variances.

TABLE 9

Summary of Analysis of Variance for Phase I Number of Targets Identified

Source of Variances	SS	df	MS	F
1. Between subjects				
a. Materials	69.2	3.	23.07	46.13*
Subjects within groups	5.	10.	0.5	
2. Within subjects				
b. Train/Test	211.6	1.	211.6	423.2**
Interaction a x c	69.2	3.	23.07	46.13*
b x subjects within groups	5.	10.	.5	

harmonic mean, n=3.2

$^*F_{.99}(3, 10) = 13.1$

$^{**}F_{.99}(1, 10) = 20.$

TABLE 10

Tests on Simple Main Effects for Phase I Number of Targets Identified

Simple Main Effects	SS	df	MS	F
1. Materials by				
Test	138.4	3.	46.13	92.3*
Error, within cell	10.	20.	0.5	–
2. Train/Test by				
a. Aluminum (A)	0.4	1.	0.4	0.8
b. Clear Base (C)	48.4	1.	48.4	96.8**
c. Carbon Black (B)	102.4	1.	102.4	204.8**
d. Green Dye (G)	129.6	1.	129.6	259.2**
Error within subjects	5.	10.	0.5	–

harmonic mean, n = 3.2 (Table 9)

*$F_{.99}(3, 20) = 10.36$

**$F_{.99}(1, 10) = 20.$

TABLE 11

Tests on Means for Materials by Test Effects Using Newman-Keuls Procedure for Phase I Number of Targets Identified

Materials	A	C	B	G
Ordered Means	8.5	3.5	1.0	0.
A	–	5.0*	7.5*	8.5*
C		–	2.5*	3.5*
B			–	1.0
G				–

harmonic mean, n = 3.2 (Table 9)

$MS_{w.c.} = 0.5$ (Table 10)

*.05 level of significances for studentized range statistic, $g_{.95}(r, 20)$ where r is the number of steps separating materials.

TABLE 12

Trend of Means for Materials by Test Effect Using Orthogonal Coefficients for Phase I Number of Targets Identified

Material Mean Value	A 8.5	C 3.5	B 1.0	G 0.	c^2	C	D	SS	F
Linear	-3	-1	1	3	20	-89.6	64.	125.4	250.9*
Quadratic	1	-1	-1	1	4	12.8	12.8	12.8	25.6*
Cubic	-1	3	-3	1	20	3.2	64.	.16	.32

harmonic mean, n = 3.2

$MS_{w.c.} = 0.5$ (Table 10)

$*F_{.99}(1, 20) = 16.2$

The analyses of variance for the detection times is summarized in Table 13. The results show that there was significant difference between the detection times for the training and testing phases. The differences among the materials and the interactions are significant at the 0.10 level.

TABLE 13

Summary of Analysis of Variance for Phase I Detection Times

Sources of Variance	SS	df	MS	F
1. Between subjects				
a. Materials	141389.4	3.	47129.8	6.01*
Subjects within groups	78448.6	10.	7844.9	
2. Within subjects				
b. Train/Test	477051.1	1.	477051.1	93.95**
Interactions a x b	154180.3	3.	51393.4	10.12*
b x subjects within groups	50774.9	10.	5077.5	

harmonic mean = n=3.2

$*F_{.90}(3, 10) = 5.46$

$**F_{.99}(1, 10) = 20.$

The analysis of variance for the centering errors is summarized in Table 14. The results show that there are significant differences among the materials, the training and test phases, and the interactions. Similar analyses for the detection errors and identification errors show no significant differences and the results are not summarized.

TABLE 14

Summary of Analysis of Variance for Phase I Centering Errors

Sources of Variances	SS	df	MS	F
1. Between subjects				
a. Materials	280807.9	3.	93602.6	33.6*
Subjects within groups	27052.6	10.	2785.3	
2. Within subjects				
b. Train/Test	615367.2	1.	615362.2	278.3**
Interactions a x b	282678.3	3.	94226.1	42.6*
b x subjects within groups	22109.59	10.	2210.9	

harmonic mean, n=3.2

$*F_{.99}(3, 10) = 13.1$

$**F_{.99}(1, 10) = 20.$

In summary, the results show that significant differences occurred during the first phase of testing and that the green dye and black carbon are the most effective materials of those tested. This is true for obscuring targets from detection and identification.

Phase II, Materials By Area

The analysis of variance for the number of targets detected is summarized in Table 15. The analysis shows significant differences among the materials, areas of coverage, training and testing phases and the interactions. The simple interaction effects were analyzed and are summarized in Table 16. The materials by area interactions are significantly different during the test phase but not during the training. Inspection of the data shows that there is no difference between the uncoated slides used during training and the carbon-black and green dye at 0.3 area coverage, and the carbon-black at 0.8 area coverage.

TABLE 15

Summary of Analysis of Variance for Phase II Number of Targets Detected

Sources of Variance	SS	df	MS	F
1. Between subjects				
a. Materials	10.92	1.	10.92	36.78*
b. Area Coverage	73.66	2.	36.83	124.06**
Interaction a x b	10.39	2.	5.19	17.49**
Subjects within groups	2.38	8.	0.29	
2. Within subjects				
c. Train/Test	90.01	1.	90.01	303.19*
Interaction a x c	10.92	1.	10.92	36.78*
Interaction b x c	73.66	2.	36.83	124.06**
Interaction a x b x c	10.39	2.	5.19	17.49**
c x subjects within groups	2.37	8.	0.29	

harmonic mean, n = 2.18

$*F_{.99}(1, 8) = 22.6$

$**F_{.99}(2, 8) = 17.3$

TABLE 16

Tests on Simple Interaction Effects of Phase II Number of Targets Detected

Simple Interaction Effects	SS	df	MS	F
1. Material and area by				
Test	189.77	2.	94.89	319.58*
Error within cell	4.75	16.	0.29	–
2. Material and cycle by				
a. Area 0.3	0.	1.	0.	0.
b. Area 0.8	58.86	1.	58.86	198.25**
c. Area 1.0	147.24	1.	147.24	495.92**
Error within subjects	2.37	8.	0.29	–
3. Area and cycle by				
a. Carbon Black (B)	95.48	2.	47.74	160.79**
b. Green Dye (G)	173.31	2.	86.65	291.86**
Error within subjects	2.37	8.	0.29	–

harmonic mean, n = 2.18

$^{*}F_{.99}(2, 16) = 12.46$

$^{**}F_{.99}(1, 8) = 22.6$

$^{**}F_{.99}(2, 8) = 17.3$

The means for the coated slides used in the test phase were compared using the Newman-Keuls procedure. The results in Table 17 show that carbon black and green dye at unity coverage, and the green dye at 0.8 coverage are significantly different from each other and the cluster of remaining slides which are equivalent to the training in performance. A trend analysis of the means for the material by area interactions was conducted using orthognal coefficients. The cell frequencies are unequal and the harmonic mean was used in this analysis. The orthogonal coefficients for the different trends do not satisfy the orthogonality condition in this case. Although the correlation coefficient is small, the analysis suggests that the trend is described by a linear by quadratic function.

TABLE 17

Tests on Means for Material-Area Interaction by Test Effect Using Newman-Keuls Procedure for Phase II Number of Targets Detected

Material-Area	G.3	G.8	B1.	G1.
Ordered Means	9.	3.	1.75	0.
G.3	–	6.*	7.25*	9.*
G.8			1.25*	3.*
B1.			–	1.75*
G1.				–

harmonic mean, n = 2.18 (Table 15)

$MS_{w.c.}$ = 0.29 (Table 15)

*.05 level of significance for studentized range statistic, $q_{.95}(r,16)$, where r is the number of steps separating means.

Inspection shows that the variances for the between subjects error and the within subjects error cannot be strictly homogeneous. No targets were detected with the green dye at unity coverage. All targets were detected with the uncoated slides used in training and the carbon-black slides at 0.3 and 0.8 coverage and the green dye slide at 0.3 coverage. Consequently, these slides were insensitive to test conditions. The variances for these slides equal zero and the Hartley test or the Bartlett's test cannot be satisfied. However, the variances for the remaining slides are numerically small and the F-test is robust in cases of mild nonhomogeneity.

Similar remarks apply to the analysis of variance for the number of targets identified. The analysis summarized in Table 19 shows significant differences among the materials, areas, training and testing phases and the interactions. An analysis of the simple interaction effects is summarized in Table 20. The means for the material by area interactions in the test phase are compared in Table 21. The results are similar to those for the number of targets detected except that there is no difference between the carbon black and green dye at unity coverage. A trend analysis using orthogonal coefficients is summarized in Table 22. The analysis suggests that a linear by quadratic function is appropriate for this selection of materials and area. Similar comments apply to the homongeneity of error variances.

TABLE 18

Trend of Means for Material-Area Interaction by Test Effect Using Orthogonal Coefficients for Phase II Number of Targets Detected

Mean Values				Orthogonal			Analysis				
	area			coefficients							
	.3	.8	.1	a. Linear x linear			c^2	C	$C^2.\bar{n}$	SS	F
material B	9.	9.	1.75	1	0	-1	4	-1.75	6.67	1.67	5.62
G	9.	3.	0.	-1	0	1					
				b. Linear x Quadratic							
				-1	2	-1	12	10.25	229.	19.09	64.3*
				1	-2	1					

harmonic mean, $\bar{n}$ = 2.18

$MS_{w.c.}$ = 0.29 (Table 16)

*$F_{.99}(1, 16)$ = 19.06

TABLE 19

Summary of Analysis of Variance for Phase II Number of Targets Identified

Sources of Variance	SS	df	MS	F
1. Between subjects				
a. Materials	8.91	1.	8.91	35.64*
b. Area Coverage	81.09	2.	40.54	162.18**
Interaction a x b	11.27	2.	5.64	22.54**
Subjects within groups	2.0	8.	0.25	
2. Within subjects				
c. Train/Test	96.18	1.	96.18	384.73*
Interaction a x c	8.91	1.	8.91	35.64*
Interaction b x c	81.09	2.	40.54	162.18**
Interaction a x b x c	11.27	2.	5.64	22.54**
c x subjects within groups	2.	8.	0.25	

harmonic mean, $\overline{n} = 2.18$

$^{*}F_{.99}(1,8) = 22.6$

$^{**}F_{.99}(2,8) = 17.3$

TABLE 20

Tests on Simple Interaction Effects of Phase II Number of Targets Identified

Simple Interaction Effects	SS	df	MS	F
1. Material and area by				
Test	202.38	2.	101.19	404.75*
Error within all	4.	16.	0.25	–
2. Material and cycle by				
a. Area 0.3	0.	1.	0.	0.
b. Area 0.8	58.86	1.	58.86	235.44**
c. Area 1.0	158.59	1.	158.59	634.38**
Error within subjects	2.0	8.	0.25	–
3. Area and cycle by				
a. Carbon Black (B)	116.27	2.	58.13	235.53**
b. Green Dye (G)	173.31	2.	86.66	346.62**
Error within subjects	2.0	8.	0.25	–

harmonic mean, n = 2.18

*$F_{.99}$ (2,16) = 19.1

**$F_{.99}$ (1,8) = 22.6

**$F_{.99}$ (2,8) = 17.3

TABLE 21

Tests on Means for Material-Area Interaction by Test Effect Using Newman-Keuls Procedure for Phase II Number of Targets Identified

Material-Area	G.3	G.8	B1.	G1.
Ordered Means	9.	3.	1.	0.
G.3	–	6.*	8.*	9.*
G.8		–	2.*	3.*
B1.			–	1.
G1.				–

harmonic mean, n = 2.18 (Table 19)
$MS_{w.c.}$ = 0.25 (Table 20)
*.05 level of significance for studentized range statistic, $q_{.95}(r,16)$, where r is the number of steps separating means.

TABLE 22

Trend of Means for Material-Area Interaction by Test Effect Using Orthogonal Coefficients for Phase II Number of Targets Identified

Mean Values	area .3	.8	.1	Orthogonal coefficients			Analysis c^2	C	$C.^2\bar{n}$	SS	F
				a. Linear x linear							
material B	9.	9.	1.	1	0	-1	4	-1	2.18	.54	2.18
G	9.	3.	0.	-1	0	1					
				b. Linear x quadratic							
				-1	2	-1	12	11.	263.78	21.98	87.93*
				1	-2	1					

harmonic mean, $\bar{n} = 2.18$

$MS_{w.c.} = 0.25$ (Table 20)

$^*F_{.99}(1,16) = 19.06$

The analysis of variance for the detection times is summarized in Table 23. The results show that there are significant differences among the area coverage, training and testing phases, and their interactions. The differences among the materials and their interaction with the training and testing are significant at the 0.10 level.

The analysis of variance for the centering errors is summarized in Table 24. The results show that there are significant differences among the materials, area coverage, training and test phases, and most of the interactions. Similar analysis for the detection errors and identification errors show no significant differences and the results are not summarized.

In summary, the results show that significant differences occurred during the second phase of testing and that the carbon-black material required more than 0.8 coverage to be effective and the geen dye at least 0.8 coverage. This is true for obscuring targets from detection and identification.

The use of a parametric test to determine statistical significance may be questioned for two reasons. Only a few subjects were used in some test cells, and some of the test cells are insensitive to the test conditions. Originally, four subjects were scheduled for each test cell but a scarcity of available subjects midway through the test forced the use of two subjects per cell. A suitable nonparmetric test is the Friedman two-way analyses of variance (Hoel, 1971; Siegel, 1956). The test uses matched subjects; however, the subject pool is not readily matched by visual acuity. Consequently, the statistical significance is not readily checked by the nonparametric test.

TABLE 23

Summary of Analysis of Variance for Phase II Detection Times

Sources of Variance	SS	df	MS	F
1. Between subjects				
a. Materials	45354.6	1.	45354.6	9.58†
b. Area Coverage	186604.64	2.	93302.32	19.71**
Interaction a x b	42512.94	2.	21256.47	4.49
Subjects within groups	37874.29	8.	4734.28	
2. Within subjects				
c. Train/Test	358224.24	1.	358224.24	111.0*
Interaction a x c	58586.64	1.	58586.64	18.15†
Interaction b x c	154248.30	2.	77124.15	23.9**
Interaction a x b x c	41705.54	2.	20852.77	6. 46
c x subjects within groups	25817.89	8.	3227.24	

harmonic mean, $\bar{n} = 2.18$

$^{\dagger}F_{.90}\ (1,8) = 6.92$

$^{*}F_{.99}\ (1,8) = 22.6$

$^{**}F_{.99}\ (2,8) = 17.3$

TABLE 24

Summary of Analysis of Variance for Phase II Centering Errors

Sources of Variance	SS	df	MS	F
1. Between subjects				
a. Materials	42014.54	1.	42014.54	29.17*
b. Area Coverage	299234.86	2.	149617.43	103.86**
Interaction a x b	41812.76	2.	20906.5	14.51
Subjects within groups	11524.03	8.	1440.5	
2. Within subjects				
c. Train/Test	351616.51	1.	351616.51	367.26*
Interaction a x c	44834.39	1.	44834.39	46.82*
Interaction b x c	286720.59	2.	143360.29	149.74**
Interaction a x b x c	41359.92	2.	20679.96	21.6**
c x subjects within groups	7659.15	8.	957.39	

harmonic mean, n = 2.18

*$F_{.99}(1,8) = 22.6$

**$F_{.99}(2,8) = 17.3$

DISCUSSION

The mean number of targets detected and identified in the Phase I testing are listed in Table 25. The table is a summary of the data listed in Tables 7 and 11 and uses the same notation. The table shows that a slight decrement in detection and identification occurs with the aluminum material. On the average, each subject detected and identified 8.5 targets out of nine. As noted below, this may have been due to extraneous factors rather than the material itself. In any case, the aluminum slide was not signficicantly different from the uncoated slides used in training (see results, above).

TABLE 25

Mean Number of Targets Detected and Identified in the Phase I Testing

	Material			
	A	C	B	G
Detected	8.5	5.75	1.75	0.
Identified	8.5	3.5	1.0	0.

The clear base causes a moderate decrement in detection and a more severe decrement in identification. A study of the recorded data shows that the triangular target was highly visible independent of range. In contrast, the visibility of the square and circular targets was range dependent. The number of these targets detected decreases with increasing range. The triangle was occasionally confused with the other panels and the few bushes on the range. The square and circle were just as likely to be confused with each other or the bushes, as identified correctly.

The carbon black caused a severe decrement in target detection and identification. The visibility of all targets were range dependent. Targets detected were just as readily confused with the other targets as they were correctly identified.

The mean number of targets detected and identified in the Phase II testing are listed in Table 26. The table is a summary of the data in Tables 17 and 21 and uses the same notation. The table shows that the green dye at 80% area coverage caused a severe decrement in target visibility. The recorded data shows that targets were only seen by those subjects who looked through the telescope at an angle to the visual axis. In this viewing mode, the obstructing coating is seen to one side leaving a high visibility zone with a restricted field of view. The targets seen were in a sector of the range extending from -1.4 to 12.2 degrees about the central axis. Targets to the left and right of this sector were not seen.

TABLE 26

Mean Number of Targets Detected and Identified in the Phase II Testing

a. detected

		area		
		1.0	0.8	0.3
MATERIAL	B	1.75	9.	9.
	G	0.	3.	9.

b. identified

		area		
MATERIAL		1.0	0.8	0.3
	B	1.0	9.	9.
	G	0.	3.	9.

The mean detection and identification ranges are listed in Table 27 for the two test phases as a function of material and area. The ranges for the clear base material are separated into those for the triangular target and the circular and square targets. The mean ranges are calculated by summing the ranges of those targets detected or identified and dividing by the total possible number of 36. The results are in agreement with Tables 25 and 26.

TABLE 27

Mean Detection (RD) and Identification (RI) Ranges in Meters

a. Phase I

		RD	RI
Material	A	304.15	304.15
	C*	196.2	114.16
	C(T)	276.92	168.28
	C(C,S)	155.84	87.10
	B	31.84	17.16
	G	0.	0.

b. Phase II

	area	RD	RI
Material G	1.0	0.	0.
	0.8	125.25	125.25
	0.3	317.46	317.46
B	1.0	31.84	17.16
	0.8	317.46	317.46
	0.3	317.46	317.46

*Ranges for clear base material, C, separated into those for the triangular target, C(T), and the circular and square targets, C(C,S).

The mean detection times for those targets detected are listed in Table 28 for the two test phases as a function of material and area. The data shows a moderate increase in detection times at even the small values of area coverage. The detection times increase with increasing coverage and the obscuring effectiveness of the material as determined by Table 25. (See Figure 3 for a plot of the mean detection times as a function of material and area.)

TABLE 28

Mean Detection Times for Those Targets Detected as a Function of Material and Area for Test Phases I and II

a. Phase I

Mean Times (Seconds)

		Train*	Test
Material	A	5.82	10.77
	C	8.61	19.88
	B	5.58	22.56
	G	5.63	----

b. Phase II

Mean Times (Seconds)

		Area	Train*	Test
Material	G	1.0	5.63	---
		0.8	3.70	39.75
		0.3	2.50	6.43
	B	1.0	5.58	22.56
		0.8	5.52	12.38
		0.3	4.52	8.49

*Grand Mean, 5.235 seconds

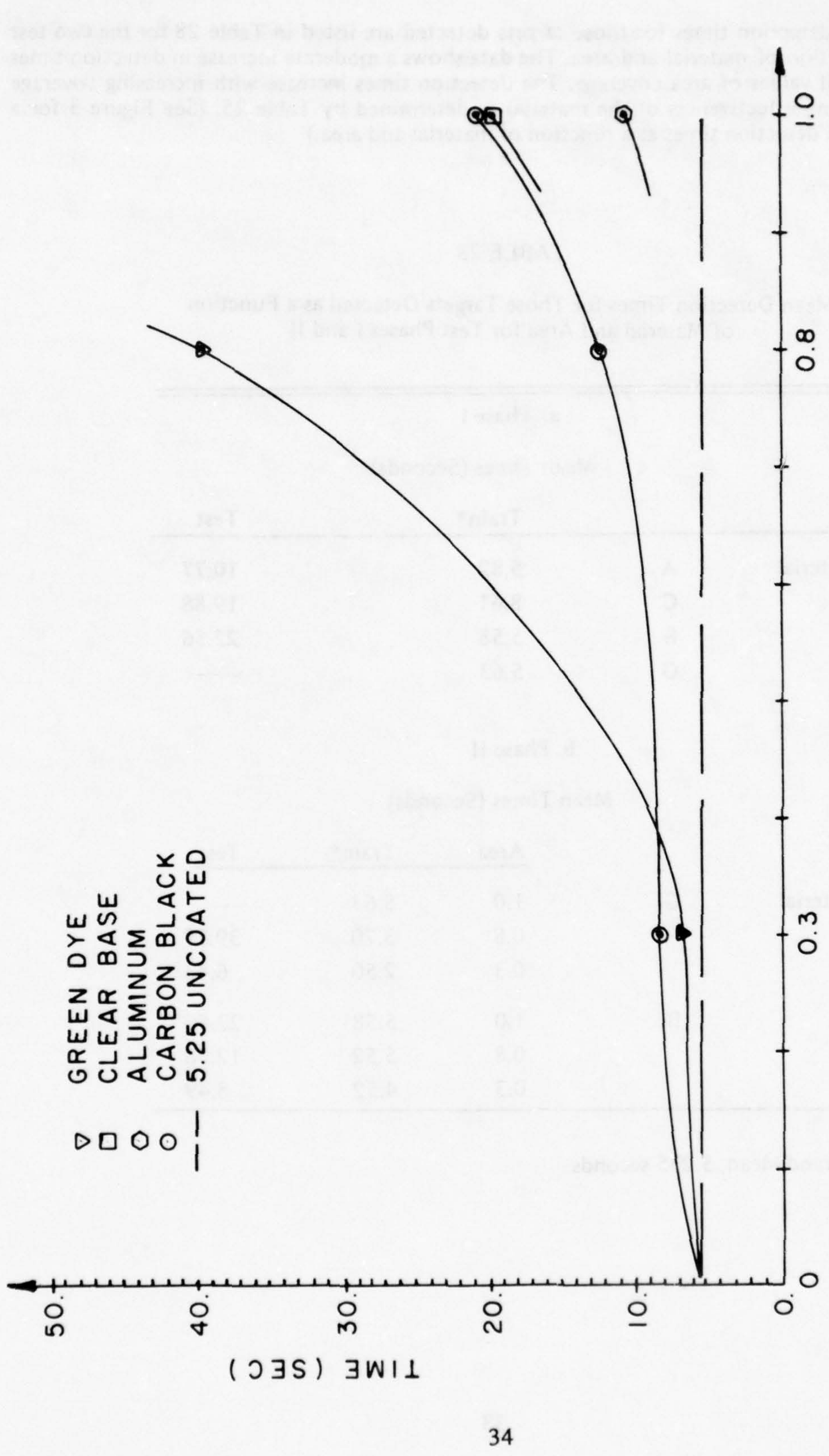


Figure 3. Mean detection time for targets detected as a function of material and area.

Interesting enough, Table 28 shows that the mean detection time of the test phase of a material is more than twice that for the training of those subjects assigned to the material. This is true even for those materials that are ineffective or low in coverage. Unfortunately, the subject size is too small for more definitive conclusions. Furthermore, the target positions were not randomized among the training cycles. However, a comparison of training cycles suggest that the target deployment of cycles T1 and T3 (see Tables 1A and 2A) were similar to those of the test cycles T4 through T6. The training cycle T2 is different since two targets could be within the telescopic field of view at the same time. However, discarding one target from T2 and increasing the training detection time by 1.125 causes no real change in the ratio of testing to training detection times. (See Figure 4 for a plot of detection times adjusted for the corresponding training times.)

The advantage of obscuring optics with aerosol coatings may be an increase in target detection times rather than complete obscuration of the target. Coatings slight in thickness and coverage may prove to be effective if measured by this performance index.

The mean centering errors for the targets detected are listed in Table 29 for the test phases I and II as a function of the materials and area. The data shows, that except for the green dye at 80% and full coverage, the materials caused a decrease in centering errors. The training errors for the subject assigned to a material exceeds the test error for the material. Apparently, the materials forced the subjects to be more exacting in their centering tasks.

In contrast, the test error for the green dye at 80% coverage is twice the training error for the subjects assigned to the slide. Since the coating obscured the target image along the visual axis, the subjects had to estimate the location of the target center. Although the subjects were able to detect some targets by an off-axis search mode, they were not able to accurately center on the targets. (See Figure 5 for a plot of mean centering error as a function of material and area.)

The view through the telescope varied with the slide inserted. The aluminum slide added a frosted, white veil over the image. The brightness and resolution of the image were both slightly reduced. On the other hand, the clear base slide markedly decreased the resolution of the instrument without changing the image brightness. The images appeared fuzzy with all sharp corners round. The carbon black slide (full coverage) appeared to severely attenuate the amount of light reaching the telescopic image. The green dye slide (full coverage) completely replaced the image light with a diffused, yellowish, white haze.

The carbon-black slide at 30% coverage had little effect upon the image. The viewer appeared to be looking around a patch of decreased brightness. Similar comments apply to the carbon-black slide at 80% coverage, except that the image was further decreased in brightness. In contrast, the green dye slide at 30% coverage appeared to add a white, diffused fog to the image light. The green dye at 80% coverage appeared to completely block the image light and replace it with a diffused source. However, it was possible to look around the obscuration by looking off the visual axis. The result was a sharply reduced field of view with little effect on the image.

The two targets not seen with the aluminum slide were missed by one subject on a single test cycle. It is possible that the targets were blown over by gusty winds which occurred during this cycle. The tester could not find the targets when confirming the bearings, and they had to be re-erected by the ground crew. If so, then the error of omission is due to extraneous factors rather than the subject. Sandbags were placed on all target frames on subsequent tests.

All subjects tested on the clear base material preferred to identify the target and center the reticle on the target image at the low magnification. One subject increased image resolution by readjusting the focus ring after the slide was inserted. The decrease in resolution caused by the clear-base slide could account for the error in identification associated with this slide.

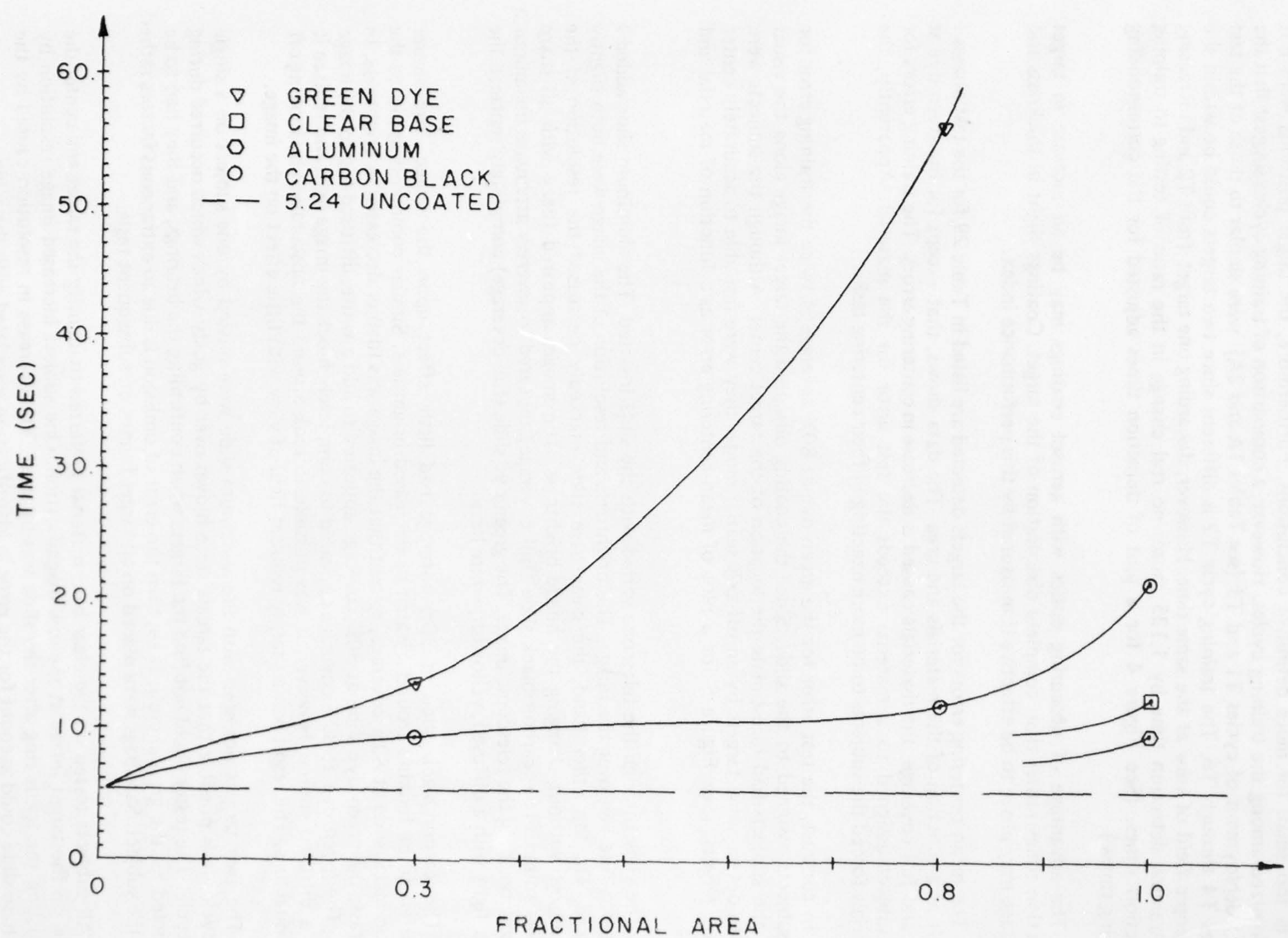


Figure 4. Adjusted mean detection time for targets detected as a function of material and area.

TABLE 29

Mean Centering Errors for Those Targets Detected as a Function of Material and Area for Test Phases I and II

a. Phase I

Mean Errors (Degrees)

		Train*	Test
Material	A	0.71	0.23
	C	0.88	0.55
	B	1.30	0.33
	G	0.32	---

b. Phase II

Mean Errors (Degrees)

		Area	Train*	Test
Material	G	1.0	0.32	—
		0.8	0.23	0.44
		0.3	0.30	0.16
	B	1.0	1.30	0.33
		0.8	0.27	0.19
		0.3	0.17	0.21

*Grand Mean, 0.5225

The six targets detected with the green dye at 80% coverage were seen by two subjects who viewed at an angle to the visual axis. They were able to detect and identify some of the targets in this manner but, they could not center the reticle over target images. They would have had to view along the visual axis to do so, and the targets were then successfully obscured. These targets were treated for data recording purposes as successful detections and identifications.

The slides with material at full coverage were scaled using the Orthorator and a single observer. The slides were placed over the eyepiece one at a time and a single observer determined his distant visual acuity (right eye). The acuity varied with the slides as follows: (1) uncoated slides, 12; (2) aluminum, 10; (3) clear base, 5; (4) carbon black, 3; (5) green dye, 0. The results suggest an almost linear decrease in visual acuity with increasing effectiveness. This decrease is similar to the linear trend computed in the results section for the number of Phase I targets detected.

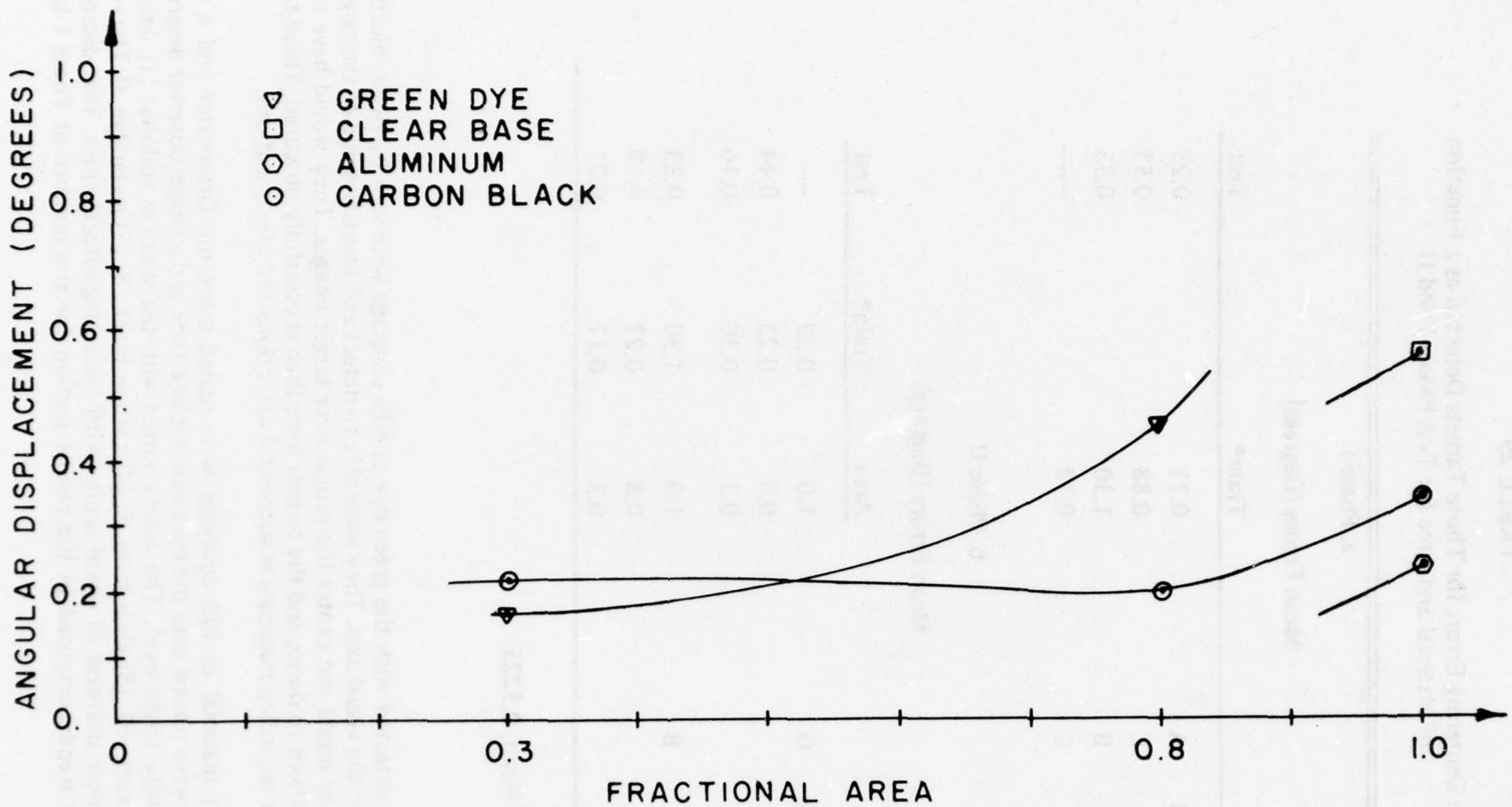


Figure 5. Mean centering error for targets detected as a function of material and area.

Interesting enough, an observer would have no trouble reading written text when the slides were placed on it. The slides would change the light-dark ratio or the color contrast but the text was clearly legible through them. A study of the slides under a microscope showed a clear base with a random scattering of widely dispersed minute particles imbedded in the material. The clear base had no such particles but the surface texture appeared uneven in contrast to the others.

The panel targets were used in the experiment because of convenience and availability. At a later date, a M113 Armored Personnel Carrier was used as a test target for two test cycles. The green dye and carbon black at 30% coverage and 80% coverage were tested with four subjects, one assigned to each slide. The results, although not analyzed statistically, are in general agreement with those for the panel targets.

The subjects were instructed to search for the target and identify the orientation in each test cycle. The M133APC was first driven to post no. 13 (282 meter line) and positioned at a 45-degree oblique angle for the second test cycle. The two subjects using the carbon black and green dye slides at 30% coverage successfully located the vehicle and identified its orientation in both cycles. The subject with the carbon black slide at 80% coverage located the vehicle both times. But while correctly identifying the head on orientation, he erroneously identified the second position as a side view. Finally, the subject with the green dye at 80% coverage was unable to locate the vehicle within 60 seconds on both test cycles.

Another test was run to determine whether aerosol collected on the viewport would obscure telescopic vision. Viewport cones were constructed (tapered ellipses with major and minor axes of 1.5" x 1.25" and 3.8" x 2.25" separated by 6 inches) for mounting to the front of the slide holder. One cone was completely coated on the inside surface with the green dye. The other cone was coated with dull black. A single subject then observed the panel targets placed in test cycle pattern T6 (see Table 2A) using each of the eight test slides in turn. No change was noted in the visibility of the targets through the slides with the coated and uncoated cones. This result is in agreement with previous work on stray light in telescopic images caused by the presence of lights in the field of view (Coleman, 1947).

CONCLUSIONS

The test results show that the rank-ordering of the materials by increasing effectiveness at obscuring targets is (1)aluminum, (2)clear base, (3)carbon black, and (4) green dye. This is true at full coverage of the objective lens. The aluminum at the material density and coating thickness used in slide preparation is no more effective than the uncoated slides used in training.

The effectiveness of the carbon black and green dye materials increases with increasing area coverage. Both materials are ineffective at 30% area coverage. The carbon black is only effective for coverages greater than 80%. The green dye is effective at 80% coverage and greater. The green dye is more effective than the carbon black at the same area coverage above 80%.

The materials have little effect upon centering error unless it obscures the target. However, the presence of the materials doubles the detection times if the materials is ineffective at obscuring the target.

In conclusion, a sticky aerosol used to obscure telescopic vision must cover more than 80% of the scope face to be effective. This is true for the materials and thickness used in slide preparation for this test. The most effective material forms a crystalline structure on the scope face. This material scatters light into the telescopic image of the target. However, the molecular weight of such materials may be too high to be incorporated into an aerosol deliver system.

FURTHER RESEARCH

Recommend that the following be investigated for further development:

1. The HEL developed computer model for obscured telescopic vision be verified using the field test data and measurements of the field test conditions.

2. The effects of low coverage coatings upon target detection times be pursued further. Recommend that a preliminary study phase employing carefully controlled conditions be conducted prior to field tests. The study would employ computer simulation techniques for target presentation, physiological monitoring of the subject's state, and careful preparation of coated materials.

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APPENDIX A

TEST ASSIGNMENTS

TABLE 1A

Target Post Position Coordinates

Post Number	Centerline Distance (Meters)	Angle (Degrees)
1	112.6	23.1
2	108.5	-15.0
3	124.6	-22.5
4	134.3	8.6
5	159.5	24.0
6	161.8	-3.6
7	185.4	-13.3
8	227.4	30.0
9	209.2	7.3
10	238.6	-21.5
11	269.9	-29.5
12	262.5	8.6
13	281.8	-12;6
14	316.9	13.6
15	338.9	-23.9
16	328.4	6.4
17	349.6	-2.7
18	372.4	18.8
19	382.8	-21.0
20	370.8	12.2
21	390.1	2.2
22	397.5	-1.4
23	428.0	9.9
24	440.8	-15.4
25	441.1	5.1
26	453.1	8.9
27	476.7	18.3
28	470.4	-8.7
29	489.7	-11.4
30	505.2	8.2

TABLE 2A

Assignment of Target Panels to Range Sector and Post Positions as a Function of Test Run

a. Test Sectors:

	Test Run					
	Train			Test		
Target	T1	T2	T3	T4	T5	T6
Square	II	III	II	II	I	II
Circle	I	II	III	I	II	III
Triangle	III	I	I	III	III	I

Notation-Sector I 100 meters to 233.3 meters

II 233.3 meters to 366.6 meters

III 366.6 meters to 500 meters

b. Post Positions:

	Test Run					
	Train			Test		
Sector	T1	T2	T3	T4	T5	T6
I	2	1	6	9	5	3
II	12	16	17	11	19	20
III	25	30	24	26	22	29

TABLE 3A

Assignment of Testing Order by Subject Number as a Function of Test Run

		Test Cycle			
Function	Test Run	C1	C2	C3	C4
Train	T1	S1	S3	S4	S2
	T2	S3	S4	S1	S2
	T3	S1	S2	S4	S3
Test	T4	S2	S3	S1	S4
	T5	S1	S3	S4	S2
	T6	S4	S2	S1	S3

APPENDIX B

SUBJECT INFORMATION

TABLE 1B

Subject Information

Subj.No.	Age (Yrs)	Branch	Service Rank	Service MOS	Service Yrs	Education	Experience (1)	Distant Acuity (2) Both Eyes	Distant Acuity (2) Right Eye	Color	Glasses	Dominant Hand	Test Date Tested	Test Assgnd Slide [3]
1	22	USA	E4	17B20	2½	12	N	10	10	6	N	R	10/19	UC
2	18	USA	E2	17C20	7/12	10	R	11	11	6	N	L	10/19	UC
3	17	USA	E2	12F20	11/12	9	T	9	8	6	N	L	10/19	UC
4	28	USA	E4	13B20	5	12	T	9	9	4	N	R	10/19	UC
5	22	USA	E3	12B10	2	12	T	9	8	6	Y	L	10/27	A1.0
6	17	USA	E2	12B20	5/6	12	N	12	11	6	Y	L	10/27	G1.0
7	25	USA	E5	12F20	4½	14	G	9	10	5	Y	R	10/27	B1.0
8	25	USA	E2	12B	3/4	11	N	11	8	6	N	R	10/27	C1.0
9	27	USA	E5	76W40	8	12	G	12	11	6	N	L	10/28	A1.0
10	23	USA	E5	62M20	4	12	R	12	12	6	N	R	10/28	C1.0
11	20	USA	E2	12B10	2/3	12	T	12	11	6	N	R	10/29	A1.0
12	23	USA	E4	76W20	4	12	T	10	10	2	N	R	10/29	C1.0
13	19	USA	E2	12F20	1	12	G	11	10	6	N	R	10/29	B1.0
14	23	USA	E3	11C10	6	12	T	9	8	6	Y	R	10/29	G1.0
15	18	USMC	E3	2141	¼	12	N	12	9	6	N	R	11/5	B1.0
16	17	USMC	E3	3521	7/12	10	R	11	10	6	N	R	11/5	A1.0
17	19	USMC	E3	3521	3/4	12	R	12	12	6	N	R	11/5	B1.0
18	19	USMC	E3	2100	5/12	12	R	12	10	6	N	L	11/5	C1.0
19	21	USA	E4	11E10	2½	12	G	12	12	6	Y	R	11/15	B.8
20	27	USA	E4	11E10	1½	12	G	12	10	6	N	R	11/15	G.8
21	28	USA	E4	11D10	8	16	N	11	9	6	N	R	11/15	G.3
22	24	USA	E4	11E10	4	12	G	9	9	4	Y	R	11/15	B.3
23	22	USA	E5	11B20	3	12	G	9	9	4	N	R	11/16	G.8
24	21	USA	E4	11E10	3 1/3	12	G	9	8	1	Y	L	11/16	B.8
25	23	USA	E4	11E10	4	12	T	12	11	6	Y	R	11/16	B.3
26	19	USA	E4	11E10	2½	12	G	12	12	6	N	R	11/16	G.3

TABLE 1B (Continued)

Notation Keys:

(1) Experience N-None

G-Main gunner, armored vehicle

R-Rifle scopes

T-Other Tests by MTD

(2) Distance Acuity

Both eyes - Bausch & Lomb Slide F-3

Right Eye - Slide F-4

Color Vision - Slide F-7

Snellen equivalency to visual acuity notation is as follows:

8-20/25

9-20/22

10-20/20

11-20/18

12-20/17

(3) Assigned slide -

Material: UC - uncoated slide, clear glass

A - Aluminum pigment

B - Lampblack in oil

C - Clear Base without pigment

G - Green dye

Coverage: 1.0 - 100 percent

0.8 - 80 percent

0.3 - 30 percent

APPENDIX C

TEST DATA AND ANALYSIS

The data is reduced and analyzed using the computer program attached below. The program reads in the recorded test data, computes the analysis of variances for the measures of interest, and prints out the corresponding summary tables and the summary of analysis of variance. The program is written for a third order factorial experiment with repeated measures on the third factor, unequal cell frequencies and fixed factors. The program uses the technique of unweighted means and harmonic means for computing the sums of squares. The analyses of simple main effects, tests on means and trends were calculated by hand from the summary tables. The recorded data for the field test covered in this report are listed with the program.

The main program and subroutines of the computer program are listed below:

1. TET - main program calls for read in of recorded data, printout of data and statistical analysis of the measures of interst.

2. RDATA - reads in recorded data on cards. Called by TET.

3. PRINT - prints out recorded data. Called by TET.

4. MAT - establishes format for analysis of test phase I data per measure called by TET.

6. SETM - reduces data for measure called by MAT or MATA.

7. MATF - establishes format for analysis of training phase data per measure called by TET.

8. SETMF - reduces data for measure called by MATF.

9. STAT - prints out summary tables, computes and prints out summary of analysis of variance for appropriate statistical format. Called by MAT, MATA, and MATF'

10. AOW - computes analysis of variance for three factorial experiment with repeated measures on third factor (trials), unequal cell frequencies and fixed factors. Called by STAT.

```
      PROGRAM TET(INPUT,OUTPUT,TAPE3=OUTPUT,TAPE2=INPUT)
      DATA DSY,DSN,PS/2HYE,2HNO,2HYE/
      READ(2,990)DO
      READ(2,990)PO
  990 FORMAT(1A2)
      IF(DO.EQ.DSY)CALL RDATA
      IF(PO.EQ.DSY)CALL PRINT
C MAINLINE--STATISTICAL ANALYSIS OF FIELD TEST DATA, ANALYSIS OF VARIANCE
      WRITE(3,1000)
 1000 FORMAT(2X,'PHASE I ANALYSIS')
      WRITE(3,1001)
 1001 FORMAT(6X,'NUMBER DETECTED')
      CALL MAT(2HND)
      WRITE(3,1002)
 1002 FORMAT(6X,'NUMBER IDENTIFIED')
      CALL MAT(2HNI)
      WRITE(3,1003)
 1003 FORMAT(6X,'DETECTION TIMES')
      CALL MAT(2HDT)
      WRITE(3,1004)
 1004 FORMAT(6X,'CENTERING TOLERANCES')
      CALL MAT(2HCT)
      WRITE(3,1005)
 1005 FORMAT(6X,'DETECTION ERRORS')
      CALL MAT(2HDE)
      WRITE(3,1006)
 1006 FORMAT(6X,'IDENTIFICATION ERRORS')
      CALL MAT(2HIE)
      WRITE(3,2000)
 2000 FORMAT(2X,'PHASE II ANALYSIS')
      WRITE(3,1001)
      CALL MATA(2HND)
      WRITE(3,1002)
      CALL MATA(2HNI)
      WRITE(3,1003)
      CALL MATA(2HDT)
      WRITE(3,1004)
      CALL MATA(2HCT)
      WRITE(3,1005)
      CALL MATA(2HDE)
      WRITE(3,1006)
      CALL MATA(2HIE)
      WRITE(3,3000)
 3000 FORMAT(2X,'TRAINING ANALYSIS')
      WRITE(3,1003)
      CALL MATF(2HDT)
      WRITE(3,1004)
      CALL MATF(2HCT)
      STOP
      END


      SUBROUTINE RDATA
C READS IN FIELD TEST DATA FOR ANALYSIS
      COMMON/CYO/ISO(10,6,4),NC,NR
      COMMON/TGT/STT(10,6,3),ELT(10,6,3),BZT(10,6,3)
      COMMON/SUBD/NT,NS(10),AV(10,4),TS(10,4),AS(10,4),ITD(10,4,6)
      COMMON/TESTD/DT(40,6,3),EL(40,6,3),BZ(40,6,3),SHL(40,6,3),SHH(40,6
     Q,3),ST(40,6,3)
      COMMON/TYP/AF(80)
      READ(2,998)(AF(I),I=1,40)
  998 FORMAT(40A2)
      READ(2,1000)NT,NC,NR
 1000 FORMAT(2X,4(I3,2X))
```

```
      DO 10 IT=1,NT
      READ(2,1000)NS(IT)
      KS=NS(IT)
      DO 3 IC=1,NC
      READ(2,1002)(STT(IT,IC,IR),ELT(IT,IC,IR),BZT(IT,IC,IR),IR=1,NR)
    3 CONTINUE
 1002 FORMAT(3(2X,1A2,2(2X,F5.1)))
      DO 5 IC=1,NC
      READ(2,1000)(ISO(IT,IC,IS),IS=1,KS)
    5 CONTINUE
      DO 10 IS=1,KS
      ITS=(IT-1)*4+IS
      READ(2,1004)AV(IT,IS),TS(IT,IS),AS(IT,IS)
 1004 FORMAT(F5.2,2(2X,1A2))
      READ(2,1006)(ITD(IT,IS,IC),IC=1,NC)
 1006 FORMAT(2X,6(I4,2X))
      DO 10 IC=1,NC
      DO 10 IR=1,NR
      READ(2,1007)DT(ITS,IC,IR),EL(ITS,IC,IR),BZ(ITS,IC,IR),SHL(ITS,IC,
     QIR),SHH(ITS,IC,IR),ST(ITS,IC,IR)
 1007 FORMAT(2X,3(F10.4,2X),3(1A2,2X))
   10 CONTINUE
      RETURN
      END


      SUBROUTINE PRINT
      COMMON/CYO/ISO(10,6,4),NC,NR
      COMMON/TGT/STT(10,6,3),ELT(10,6,3),BZT(10,6,3)
      COMMON/SUBD/NT,NS(10),AV(10,4),TS(10,4),AS(10,4),ITD(10,4,6)
      COMMON/TESTD/DT(40,6,3),EL(40,6,3),BZ(40,6,3),SHL(40,6,3),SHH(40,
     Q6,3),ST(40,6,3)
      COMMON/TYP/AF(80)
      WRITE(3,998)(AF(I),I=1,40)
  998 FORMAT(40A2)
      WRITE(3,997)
  997 FORMAT(2X,'INPUT TEST DATA')
      WRITE(3,996)NT,NC,NR
  996 FORMAT(2X,'TEST PERIOD=',I4,2X,'CYCLES PER PERIOD=',I4,2X,'RUNS PE
     QR CYCLE=',I4)
      DO 20 IT=1,NT
      WRITE(3,995)IT,NS(IT)
  995 FORMAT(2X,'TEST PERIOD NO.',I4,2X,'SUBJECTS=',I4)
      KS=NS(IT)
      WRITE(3,1001)
 1001 FORMAT(2X,'TEST TARGET POSITIONS')
      DO 13 IC=1,NC
      WRITE(3,1002)(STT(IT,IC,IR),ELT(IT,IC,IR),BZT(IT,IC,IR),IR=1,NR)
 1002 FORMAT(3(2X,1A2,2(2X,F5.1)))
   13 CONTINUE
      WRITE(3,1003)
 1003 FORMAT(2X,'SUBJECT TEST ORDER')
      DO 15 IC=1,NC
      WRITE(3,1000)(ISO(IT,IC,IS),IS=1,KS)
 1000 FORMAT(2X,4(I3,2X))
   15 CONTINUE
      DO 20 IS=1,KS
      ITS=(IT-1)*4+IS
      WRITE(3,1005)IS,AV(IT,IS),TS(IT,IS),AS(IT,IS)
 1005 FORMAT(2X,'SUBJECT=',2X,I4/2X,'ACUITY=',2X,F10.4,'TEST MATERIAL=',
     Q2X,1A2,2X,'TEST AREA=',2X,1A2)
      WRITE(3,992)
  992 FORMAT(2X,'TEST CYCLE TIMES')
```

```
      WRITE(3,1006)(ITD(IT,IS,IC),IC=1,NC)
 1006 FORMAT(2X,6(I4,2X))
      WRITE(3,999)
  999 FORMAT(2X,'TEST RUN DATA')
      DO 20 IC=1,NC
      DO 20 IR=1,NR
      WRITE(3,1007)DT(ITS,IC,IR),EL(ITS,IC,IR),BZ(ITS,IC,IR),SHL(ITS,IC,
     0IR),SHH(ITS,IC,IR),ST(ITS,IC,IR)
 1007 FORMAT(2X,3(F10.4,2X),3(1A2,2X))
   20 CONTINUE
      RETURN
      END


      SUBROUTINE MAT(AP)
C ESTABLISHES REDUCED DATA FOR ADV
      COMMON/CYD/ISD(10,6,4),NCC,NRR
      COMMON/TGT/STT(10,6,3),ELT(10,6,3),BZT(10,6,3)
      COMMON/SUBD/NT,NS(10),AV(10,4),TS(10,4),AS(10,4),TD(10,4,6)
      COMMON/TESTD/DT(40,6,3),EL(40,6,3),BZ(40,6,3),SHL(40,6,3),SHH(40,6
     0,3),ST(40,6,3)
      COMMON/FTEST/NA,NB,NC,NNS(10,10),T(10,10,40)
      DATA T0,T1,T2,T3,T4/2H U,2H A,2H C,2H B,2H G/
      DATA A1,A2,A3,A4/2H.0,2H.3,2H.6,2H1./
      DATA NT1,NT2/2,5/
      NA=4
      NB=1
      NC=2
      NCO=NCC/2
      DO 3 I1=1,NA
      NNS(I1,1)=0
      TC=T1
      IF(I1.EQ.2)TC=T2
      IF(I1.EQ.3)TC=T3
      IF(I1.EQ.4)TC=T4
      DO 3 IT=NT1,NT2
      KS=NS(IT)
      DO 2 I=1,KS
      IF(TS(IT,I).NE.TC.OR.AS(IT,I).NE.A4)GOTO 2
      NNS(I1,1)=NNS(I1,1)+1
    2 CONTINUE
    3 CONTINUE
      WRITE(3,1000)((NNS(IA,IB),IA=1,NA),IB=1,NB)
 1000 FORMAT(2X,'SUBJECTS',2X,10(I4,2X))
      WRITE(3,1001)
 1001 FORMAT(2X,'ADV DATA')
      DO 40 I1=1,NA
      KKS=NNS(I1,1)
      II=0
      TC=T1
      IF(I1.EQ.2)TC=T2
      IF(I1.EQ.3)TC=T3
      IF(I1.EQ.4)TC=T4
      DO 30 IT=NT1,NT2
      KS=NS(IT)
      DO 20 I=1,KS
      ITS=(IT-1)*4+1
      IF(TS(IT,I).NE.TC.OR.AS(IT,I).NE.A4)GOTO 20
      II=II+1
      T(I1,1,II)=0.
      T(I1,1,II+KKS)=0.
      CALL SETM(AP,IT,I1,1,ITS,II,KKS,NCO)
   20 CONTINUE
   30 CONTINUE
```

```
      WRITE(3,1002)I1,TC,A4,(II,II=1,KKS)
 1002 FORMAT(2X,I2,2X,'MAT=',1A2,2X,'AREA=',1A2/2X,10(8X,I2,2X))
      WRITE(3,1003)(T(I1,1,II),II=1,KKS)
      WRITE(3,1003)(T(I1,1,II+KKS),II=1,KKS)
 1003 FORMAT(2X,10(F10.4,2X))
   40 CONTINUE
      CALL STAT
      RETURN
      END


      SUBROUTINE MATA(AP)
C ESTABLISHES REDUCED DATA FOR AOV
      COMMON/CYD/ISO(10,6,4),NCC,NRR
      COMMON/TGT/STT(10,6,3),ELT(10,6,3),BZT(10,6,3)
      COMMON/SUBD/NT,NS(10),AV(10,4),TS(10,4),AS(10,4),TD(10,4,6)
      COMMON/TESTD/DT(40,6,3),EL(40,6,3),BZ(40,6,3),SHL(40,6,3),SHH(40,6
     0,3),ST(40,6,3)
      COMMON/FTEST/NA,NB,NC,NNS(10,10),T(10,10,40)
      DATA T0,T1,T2,T3,T4/2H U,2H A,2H C,2H B,2H G/
      DATA A1,A2,A3,A4/2H.0,2H.3,2H.8,2H1./
      DATA NT1,NT2/2,7/
      NA=2
      NB=3
      NC=2
      NCO=NCC/2
      DO 3 I1=1,NA
      TC=T3
      IF(I1.EQ.2)TC=T4
      DO 3 I2=1,NB
      NNS(I1,I2)=0
      TA=A2
      IF(I2.EQ.2)TA=A3
      IF(I2.EQ.3)TA=A4
      DO 3 IT=NT1,NT2
      KS=NS(IT)
      DO 2 I=1,KS
      IF(TS(IT,I).NE.TC.OR.AS(IT,I).NE.TA)GOTO 2
      NNS(I1,I2)=NNS(I1,I2)+1
    2 CONTINUE
    3 CONTINUE
      WRITE(3,1000)((NNS(IA,IB),IB=1,NB),IA=1,NA)
 1000 FORMAT(2X,'SUBJECTS',2X,10(I4,2X))
      WRITE(3,1001)
 1001 FORMAT(2X,'AOV DATA')
      DO 40 I1=1,NA
      TC=T3
      IF(I1.EQ.2)TC=T4
      DO 40 I2=1,NB
      II=0
      KKS=NNS(I1,I2)
      TA=A2
      IF(I2.EQ.2)TA=A3
      IF(I2.EQ.3)TA=A4
      DO 30 IT=NT1,NT2
      KS=NS(IT)
      DO 20 I=1,KS
      ITS=(IT-1)*4+I
      IF(TS(IT,I).NE.TC.OR.AS(IT,I).NE.TA)GOTO 20
      II=II+1
      T(I1,I2,II)=0.
      T(I1,I2,II+KKS)=0.
      CALL SETM(AP,II,I1,I2,ITS,II,KKS,NCO)
   20 CONTINUE
```

```
   30 CONTINUE
      WRITE(3,1002)I1,TC,TA,(II,II=1,KKS)
 1002 FORMAT(2X,I2,2X,'MAT=',1A2,2X,'AREA=',1A2/2X,10(8X,I2,2X))
      WRITE(3,1003)(T(I1,I2,II),II=1,KKS)
      WRITE(3,1003)(T(I1,I2,II+KKS),II=1,KKS)
 1003 FORMAT(2X,10(F10.4,2X))
   40 CONTINUE
      CALL STAT
      RETURN
      END


      SUBROUTINE SETM(AP,IT,I1,I2,ITS,II,KKS,NCO)
      COMMON/CYD/ISD(10,6,4),NCC,NRR
      COMMON/TGT/STT(10,6,3),ELT(10,6,3),BZT(10,6,3)
      COMMON/SUBD/NT,NS(10),AV(10,4),TS(10,4),AS(10,4),TD(10,4,6)
      COMMON/TESTD/DT(40,6,3),EL(40,6,3),BZ(40,6,3),SHL(40,6,3),SHH(40,6
     Q,3),ST(40,6,3)
      COMMON/FTEST/NA,NB,NC,NNS(10,10),T(10,10,40)
      DO 100 IC=1,NCC
      DO 100 IR=1,NRR
      IF(AP.NE.2HND)GOTO 10
      IF(DT(ITS,IC,IR).GT.60.)GOTO 100
      IF(ST(ITS,IC,IR).EQ.2HBS)GOTO 100
      IF(IC.GT.NCO)GOTO 5
      T(I1,I2,II)=T(I1,I2,II)+1.
      GO TO 100
    5 T(I1,I2,II+KKS)=T(I1,I2,II+KKS)+1.
      GO TO 100
   10 CONTINUE
      IF(AP.NE.2HNI)GOTO 20
      IF(DT(ITS,IC,IR).GT.60.)GOTO 100
      IF(ST(ITS,IC,IR).EQ.2HBS)GOTO 100
      IF(SHH(ITS,IC,IR).NE.ST(ITS,IC,IR))GOTO 100
      IF(IC.GT.NCO)GOTO 15
      T(I1,I2,II)=T(I1,I2,II)+1.
      GO TO 100
   15 T(I1,I2,II+KKS)=T(I1,I2,II+KKS)+1.
      GO TO 100
   20 CONTINUE
      IF(AP.NE.2HDT)GOTO 30
      IF(IC.GT.NCO)GOTO 25
      T(I1,I2,II)=T(I1,I2,II)+DT(ITS,IC,IR)
      GO TO 100
   25 T(I1,I2,II+KKS)=T(I1,I2,II+KKS)+DT(ITS,IC,IR)
      GO TO 100
   30 CONTINUE
      IF(AP.NE.2HCT)GOTO 40
      DO 34 IA=1,3
   34 IF(ST(ITS,IC,IR).EQ.STT(IT,IC,IA))GOTO 37
      DE=63.24
      GO TO 38
   37 DE=SQRT((ELT(IT,IC,IA)-EL(ITS,IC,IR))**2+(BZT(IT,IC,IA)-BZ(ITS,IC,
     QIR))**2)
   38 IF(IC.GT.NCO)GOTO 39
      T(I1,I2,II)=T(I1,I2,II)+DE
      GO TO 100
   39 T(I1,I2,II+KKS)=T(I1,I2,II+KKS)+DE
      GO TO 100
   40 CONTINUE
      IF(AP.NE.2HDE)GOTO 50
      IF(ST(ITS,IC,IR).NE.2HBS)GOTO 100
      IF(IC.GT.NCO)GOTO 45
```

```
      T(I1,I2,II)=T(I1,I2,II)+1.
      GO TO 100
   45 T(I1,I2,II+KKS)=T(I1,I2,II+KKS)+1.
      GO TO 100
   50 CONTINUE
      IF(AP.NE.2HIE)GOTO 100
      DO 54 IA=1,3
   54 IF(ST(ITS,IC,IR).EQ.STT(IT,IC,IA))GOTO 57
      GO TO 100
   57 IF(SHH(ITS,IC,IR).EQ.ST(ITS,IC,IR))GOTO 100
      IF(IC.GT.NCO)GOTO 55
      T(I1,I2,II)=T(I1,I2,II)+1.
      GO TO 100
   55 T(I1,I2,II+KKS)=T(I1,I2,II+KKS)+1.
  100 CONTINUE
      RETURN
      END

      SUBROUTINE MATF(AP)
C ESTABLISHES REDUCED DATA FOR ADV
      COMMON/CYD/ISO(10,6,4),NCC,NKR
      COMMON/TGT/STT(10,6,3),ELT(10,6,3),BZT(10,6,3)
      COMMON/SUBD/NT,NS(10),AV(10,4),TS(10,4),AS(10,4),TD(10,4,6)
      COMMON/TESTD/DT(40,6,3),EL(40,6,3),BZ(40,6,3),SHL(40,6,3),SHH(40,6
     Q,3),ST(40,6,3)
      COMMON/FTEST/NA,NB,NC,NNS(10,10),T(10,10,40)
      DATA T0,T1,T2,T3,T4/2H 0,2H A,2H C,2H B,2H G/
      DATA A1,A2,A3,A4/2H.0,2H.3,2H.8,2H1./
      DATA NT1,NT2/2,7/
      NA=8
      NB=1
      NC=3
      NCO=NCC/2
      NC1=NCO/3
      NC2=2*NC1
      DO 3 I1=1,NA
      NNS(I1,1)=0
      TA=A4
      TC=T1
      IF(I1.EQ.2)TC=T2
      IF(I1.EQ.3)TC=T3
      IF(I1.EQ.4)TC=T4
      IF(I1.GE.5)TC=T3
      IF(I1.GE.7)TC=T4
      IF(I1.EQ.5.OR.I1.EQ.7)TA=A2
      IF(I1.EQ.6.OR.I1.EQ.8)TA=A3
      DO 3 IT=NT1,NT2
      KS=NS(IT)
      DO 2 I=1,KS
      IF(TS(IT,I).NE.TC.OR.AS(IT,I).NE.TA)GOTO 2
      NNS(I1,1)=NNS(I1,1)+1
    2 CONTINUE
    3 CONTINUE
      WRITE(3,1000)((NNS(IA,IB),IB=1,NB),IA=1,NA)
 1000 FORMAT(2X,'SUBJECTS',2X,10(I4,2X))
      WRITE(3,1001)
 1001 FORMAT(2X,'ADV DATA')
      DO 40 I1=1,NA
      KKS=NNS(I1,1)
      II=0
      TA=A4
      TC=T1
      IF(I1.EQ.2)TC=T2
```

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      IF(I1.EQ.3)TC=T3
      IF(I1.EQ.4)TC=T4
      IF(I1.GE.5)TC=T3
      IF(I1.GE.7)TC=T4
      IF(I1.EQ.5.OR.I1.EQ.7)TA=A2
      IF(I1.EQ.6.OR.I1.EQ.8)TA=A3
      DO 30 IT=NT1,NT2
      KS=NS(IT)
      DO 20 I=1,KS
      ITS=(IT-1)*4+I
      IF(TS(IT,I).NE.TC.OR.AS(IT,I).NE.TA)GOTO 20
      II=II+1
      T(I1,1,II)=0.
      T(I1,1,II+KKS)=0.
      T(I1,1,II+2*KKS)=0.
      CALL SETMF(AP,IT,I1,1,ITS,II,KKS,NCO,NC1,NC2)
   20 CONTINUE
   30 CONTINUE
      WRITE(3,1002)I1,TC,TA,(II,II=1,KKS)
 1002 FORMAT(2X,I2,2X,'MAT=',1A2,2X,'AREA=',1A2/2X,10(8X,I2,2X))
      WRITE(3,1003)(T(I1,1,II),II=1,KKS)
      WRITE(3,1003)(T(I1,1,II+KKS),II=1,KKS)
      WRITE(3,1003)(T(I1,1,II+2*KKS),II=1,KKS)
 1003 FORMAT(2X,10(F10.4,2X))
   40 CONTINUE
      CALL STAT
      RETURN
      END


      SUBROUTINE SETMF(AP,IT,I1,I2,ITS,II,KKS,NCO,NC1,NC2)
      COMMON/CYO/ISO(10,6,4),NCC,NRR
      COMMON/TGT/STT(10,6,3),ELT(10,6,3),BZT(10,6,3)
      COMMON/SUBD/NT,NS(10),AV(10,4),TS(10,4),AS(10,4),TD(10,4,6)
      COMMON/TESTD/DT(40,6,3),EL(40,6,3),BZ(40,6,3),SHL(40,6,3),SHH(40,6
     Q,3),ST(40,6,3)
      COMMON/FTEST/NA,NB,BC,NNS(10,10),T(10,10,40)
      DO 100 IC=1,NCO
      DO 100 IR=1,NRR
      IF(AP.NE.2HDT)GOTO 10
      IF(DT(ITS,IC,IR).GT.60.)GOTO 100
      IF(ST(ITS,IC,IR).EQ.2HBS)GOTO 100
      IF(IC.GT.NC1)GOTO 5
      T(I1,I2,II)=T(I1,I2,II)+DT(ITS,IC,IR)
      GO TO 100
    5 IF(IC.GT.NC2)GOTO 7
      T(I1,I2,II+KKS)=T(I1,I2,II+KKS)+DT(ITS,IC,IR)
      GO TO 100
    7 T(I1,I2,II+2*KKS)=T(I1,I2,II+2*KKS)+DT(ITS,IC,IR)
      GO TO 100
   10 CONTINUE
      IF(AP.NE.2HCT)GOTO 100
      DO 14 IA=1,3
   14 IF(ST(ITS,IC,IR).EQ.STT(IT,IC,IA))GOTO 17
      DE=63.24
      GO TO 18
   17 DE=SQRT((ELT(IT,IC,IA)-EL(ITS,IC,IR))**2+(BZT(IT,IC,IA)-BZ(ITS,IC,
     QIR))**2)
   18 IF(IC.GT.NC1)GOTO 25
      T(I1,I2,II)=T(I1,I2,II)+DE
      GO TO 100
   25 IF(IC.GT.NC2)GOTO 27
      T(I1,I2,II+KKS)=T(I1,II,II+KKS)+DE
```

```
      GO TO 100
   27 T(I1,I2,II+2*KKS)=T(I1,I2,II+2*KKS)+DE
  100 CONTINUE
      RETURN
      END


      SUBROUTINE STAT
      COMMON/FTEST/NA,NB,NC,NS(10,10),T(10,10,40)
      COMMON/AOV/SS(10,10,10),TA(10,10,10),TS(3,10,10),TAS(3,10),TP(20)
      CALL AOVV(XG,SSWC,XHN,NT)
      WRITE(3,1000)XG,SSWC,XHN,NT
 1000 FORMAT(1H ,'GRAND MEAN=',F10.4,2X,'SUM SQUARED SCORES=',F10.4,2X,'
     0HARMONIC MEAN=',F10.4,2X,'TOTAL SUBJECTS=',I4)
      WRITE(3,1001)(J,J=1,NC)
 1001 FORMAT(2X,'CELL MEAN SCORES'/6X,10(8X,I2,2X))
      DO 15 I=1,NA
      WRITE(3,1002)I
      DO 15 J=1,NB
   15 WRITE(3,1002)J,(TA(I,J,K),K=1,NC)
 1002 FORMAT(2X,I2,10(2X,F10.4))
      WRITE(3,1003)(J,J=1,NC)
 1003 FORMAT(2X,'CELL SUM OF SQUARED SCORES'/6X,10(8X,I2,2X))
      DO 16 I=1,NA
      WRITE(3,1002)I
      DO 16 J=1,NB
   16 WRITE(3,1002)J,(SS(I,J,K),K=1,NC)
      WRITE(3,1004)(TAS(1,I),I=1,NA)
 1004 FORMAT(2X,'SUM OF ROW MEANS'/6X,10(2X,F10.4))
      WRITE(3,1005)(TAS(2,J),J=1,NB)
 1005 FORMAT(2X,'SUMS OF COLUMN MEAN'/6X,10(F10.4,2X))
      IF(NC.GT.1)GOTO 100
C NON-REPEATED MEASURES
      DFW=NT-NA*NB
      IF(NA.GT.1.AND.NB.GT.1)GOTO 50
C SINGLE FACTOR
      XN=NT
      SSG=0.
      SSWT=0.
      IF(NB.EQ.1)GOTO 25
      DO 20 J=1,NB
      XS=NS(1,J)
      SSG=SSG+TAS(2,J)*XS
   20 SSWT=SSWT+(TAS(2,J)**2)*XS
      DFA=NB-1
      GO TO 30
   25 DO 27 I=1,NA
      XS=NS(I,1)
      SSG=SSG+TAS(1,I)*XS
   27 SSWT=SSWT+(TAS(1,I)**2)*XS
      DFA=NA-1
   30 CONTINUE
      WRITE(3,1026)SSG,SSWT,SSWC
 1026 FORMAT(2X,'SSG=',F14.4,2X,'SSWT=',F14.4,2X,'SSWC=',F14.4)
      SSG=SSG*SSG/XN
      SSA=SSWT-SSG
      SSW=SSWC-SSWT
      XMSA=SSA/DFA
      XMSW=SSW/DFW
      SST=SSWC-SSG
      F=XMSA/XMSW
      DFT=DFA+DFW
      WRITE(3,1006)SSA,DFA,XMSA,F,SSW,DFW,XMSW,SST,DFT
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1006 FORMAT(10X,'SUMMARY OF VARIANCE'/2X,'TREATMENT',4(2X,F10.4)/2X,'ER
    QROR',4X,3(2X,F10.4)/2X,'TOTAL',4X,2(2X,F10.4))
     RETURN
  50 CONTINUE
C MULTIPLE VARIABLE
     XN=NA*NB
     XN1=NA
     XN2=NB
     SSG=XG*XG/XN
     SS11=0.
     DO 51 I=1,NA
  51 SS11=SS11+(TAS(1,I)**2)/XN2
     SS22=0.
     DO 52 J=1,NB
  52 SS22=SS22+(TAS(2,J)**2)/XN1
     SSII=0.
     SSWT=0.
     DO 53 I=1,NA
     DO 53 J=1,NB
     XS=NS(I,J)
     SSWT=SSWT+(TA(I,J,1)**2)*XS
  53 SSII=SSII+TA(I,J,1)**2
     WRITE(3,1028)SSG,SS11,SS22,SSII,SSWT,SSWC
1028 FORMAT(2X,'SSG=',F14.4,2X,'SS11=',F14.4,2X,'SS22=',F14.4/2X,
    Q'SSII=',F14.4,2X,'SSWT=',F14.4,2X,'SSWC=',F14.4)
     SS1=(SS11-SSG)*XHN
     SS2=(SS22-SSG)*XHN
     SSI=(SSII-SS11-SS22+SSG)*XHN
     SSW=SSWC-SSWT
     SST=SSWC-SSG*XHN
     DF1=NA-1
     DF2=NB-1
     DFI=DF1*DF2
     XMS1=SS1/DF1
     XMS2=SS2/DF2
     XMSI=SSI/DFI
     XMSW=SSW/DFW
     F1=XMS1/XMSW
     F2=XMS2/XMSW
     FI=XMSI/XMSW
     DFT=DF1+DF2+DFI+DFW
     WRITE(3,1008)SS1,DF1,XMS1,F1,SS2,DF2,XMS2,F2,SSI,DFI,XMSI,FI,SSW,
    QDFW,XMSW,SST,DFT
1008 FORMAT(10X,'SUMMARY OF VARIANCE'/2X,'TREATMENT A',4(2X,F10.4)/2X
    Q,'TREATMENT B',4(2X,F10.4)/2X,'INTERACTIONS',1X,4(2X,F10.4)/2X,'
    QWITHIN CELL',2X,3(2X,F10.4)/2X,'TOTAL',8X,2(2X,F10.4))
     RETURN
 100 CONTINUE
C REPEATED MEASURES ON FACTOR C
     WRITE(3,2001)(TAS(3,K),K=1,NC)
2001 FORMAT(2X,'SUM OF REPEATED MEANS'/6X,10(F10.4,2X))
     WRITE(3,2002)(TP(IS),IS=1,NT)
2002 FORMAT(2X,'SUM OF SUBJECT MEANS'/6X,10(F10.4,2X))
     WRITE(3,2003)(J,J=1,NB)
2003 FORMAT(2X,'SUM OF AB MEANS'/6X,10(8X,I2,2X))
     DO 101 I=1,NA
 101 WRITE(3,1002)I,(TS(1,I,J),J=1,NB)
     WRITE(3,2004)(K,K=1,NC)
2004 FORMAT(2X,'SUM OF AC MEANS'/6X,10(8X,I2,2X))
     DO 102 I=1,NA
 102 WRITE(3,1002)I,(TS(2,I,K),K=1,NC)
     WRITE(3,2005)(K,K=1,NC)
2005 FORMAT(2X,'SUM OF BC MEANS'/6X,10(8X,I2,2X))
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      DO 103 J=1,NB
  103 WRITE(3,1002)J,(TS(3,J,K),K=1,NC)
      IF(NA.GT.1.AND.NB.GT.1)GOTO 150
      IF(NA.GT.1.OR.NB.GT.1)GOTO 130
C REPEATED MEASURES ON FACTOR C ALONE
      XN=NC
      XT=NT
      SSG=XG*XG/XN
      SSP=0.
      DO 104 IS=1,NT
  104 SSP=SSP+(TP(IS)**2)/XN
      SSBP=SSP-SSG*XT
      DFB=NT-1
      SSWP=SSWC-SSP
      DFW=NT*(NC-1)
      SSWT=0.
      DO 105 K=1,NC
  105 SSWT=SSWT+TAS(3,K)**2
      SSA=(SSWT-SSG)*XT
      DFA=NC-1
      SSR=SSWC-SSP+(SSG-SSWT)*XT
      DFR=(NT-1)*(NC-1)
      SST=SSWC-SSG*XT
      DFT=NT*NC-1
      XMSA=SSA/DFA
      XMSR=SSR/DFR
      F=XMSA/XMSR
      WRITE(3,2006)SSBP,DFB,SSWP,DFW,SSA,DFA,XMSA,F,SSR,DFR,XMSR,SST,DFT
 2006 FORMAT(10X,'ANALYSIS OF VARIANCE'/2X,'BETWEEN SUBJECTS',2(2X,F10.4
     Q)/2X,'WITHIN SUBJECTS',1X,2(2X,F10.4)/2X,'TREATMENT',7X,4(2X,F10.4
     Q)/2X,'RESIDUAL',8X,3(2X,F10.4)/2X,'TOTAL',11X,2(2X,F10.4))
      RETURN
  130 CONTINUE
C SINGLE FACTOR WITH REPEATED MEASURES ON FACTOR C
      XN=NA*NB*NC
      SSG=XG*XG/XN
      SSP=0.
      SSWA=0.
      SSWT=0.
      SSCT=0.
      SSAC=0.
      XNC=NC
      DO 131 K=1,NT
  131 SSP=SSP+(TP(K)**2)/XNC
      IF(NA.EQ.1)GOTO 135
      XNA=NA
      NAA=NA
      DO 132 I=1,NA
      XS=NS(I,1)
      SSWT=SSWT+(TAS(1,I)**2)*XS/XNC
  132 SSWA=SSWA+(TAS(1,I)**2)/XNC
      DO 133 I=1,NA
      XS=NS(I,1)
      DO 133 K=1,NC
      SSCT=SSCT+(TS(2,I,K)**2)*XS
  133 SSAC=SSAC+(TS(2,I,K)**2)
      GO TO 140
  135 CONTINUE
      XNA=NB
      NAA=NB
      DO 136 J=1,NB
      XS=NS(1,J)
      SSWT=SSWT+(TAS(2,J)**2)*XS/XNC
```

```
  136 SSWA=SSWA+(TAS(2,J)**2)/XNC
      DO 137 J=1,NB
      XS=NS(1,J)
      DO 137 K=1,NC
      SSCT=SSCT+(TS(3,J,K)**2)*XS
  137 SSAC=SSAC+TS(3,J,K)**2
  140 CONTINUE
      SSWR=0.
      DO 141 K=1,NC
  141 SSWR=SSWR+(TAS(3,K)**2)/XNA
      WRITE(3,2029)SSG,SSWA,SSWR,SSAC,SSWC,SSWT,SSCT,SSP
 2029 FORMAT(2X,'SSG=',F14.4,2X,'SSWA=',F14.4,2X,'SSWR=',F14.4,2X,'SSAC=
     Q',F14.4/2X,'SSWC=',F14.4,2X,'SSWT=',F14.4,2X,'SSCT=',F14.4,2X,'SSP
     Q=',F14.4)
      SSBP=SSP-SSG*XHN
      DFBP=NT-1
      SSA=(SSWA-SSG)*XHN
      DFA=NAA-1
      XMSA=SSA/DFA
      SSWG=SSP-SSWT
      DFW=NT-NAA
      XMSW=SSWG/DFW
      SSWP=SSWC-SSP
      DFWP=NT*(NC-1)
      SSC=(SSWR-SSG)*XHN
      DFC=NC-1
      XMSC=SSC/DFC
      SAC=(SSAC-SSWA-SSWR+SSG)*XHN
      DFAC=(NAA-1)*(NC-1)
      XMAC=SAC/DFAC
      SSCW=SSWC-SSP-SSCT+SSWT
      DFCW=(NT-NAA)*(NC-1)
      XMCW=SSCW/DFCW
      FA=XMSA/XMSW
      FC=XMSC/XMCW
      FAC=XMAC/XMCW
      WRITE(3,2010)SSBP,DFBP,SSA,DFA,XMSA,FA,SSWG,DFW,XMSW,SSWP,DFWP,SSC
     Q,DFC,XMSC,FC,SAC,DFAC,XMAC,FAC,SSCW,DFCW,XMCW
 2010 FORMAT(2X,'ANALYSIS OF VARIANCE'/2X,'BETWEEN SUBJECTS',2(2X,F14.4)
     Q/2X,'TREATMENT A',5X,4(2X,F14.4)/2X,'SUBJECTS'/2X,'WITHIN GROUPS',
     Q3X,3(2X,F14.4)/2X,'WITHIN SUBJECTS',1X,2(2X,F14.4)/2X,'TREATMENT C
     Q',5X,4(2X,F14.4)/2X,'INTERACTION AC',2X,4(2X,F14.4)/2X,'C BY SUBJE
     QCTS'/2X,'WITHIN GROUPS',3X,3(2X,F14.4))
      RETURN
  150 CONTINUE
C MULTIPLE FACTORS A AND B WITH REPEATED MEASURES ON FACTOR C
      XNA=NA
      XNB=NB
      XNC=NC
      SSWP=0.
      SSWT=0.
      SSCT=0.
      DO 151 IS=1,NT
  151 SSWP=SSWP+(TP(IS)**2)/XNC
      ABC=0.
      DO 152 I=1,NA
      DO 152 J=1,NB
      XS=NS(I,J)
      DO 152 K=1,NC
      SSCT=SSCT+(TA(I,J,K)**2)*XS
  152 ABC=ABC+TA(I,J,K)**2
      SSG=XG*XG/(XNA*XNB*XNC)
      SSSA=0.
```

```
      DO 153 I=1,NA
  153 SSSA=SSSA+(TAS(1,I)**2)/(XNB*XNC)
      SSSB=0.
      DO 154 J=1,NB
  154 SSSB=SSSB+(TAS(2,J)**2)/(XNA*XNC)
      SSSC=0.
      DO 155 K=1,NC
  155 SSSC=SSSC+(TAS(3,K)**2)/(XNA*XNB)
      SSAB=0.
      DO 156 I=1,NA
      DO 156 J=1,NB
      XS=NS(I,J)
      SSWT=SSWT+(TS(1,I,J)**2)*XS/XNC
  156 SSAB=SSAB+(TS(1,I,J)**2)/XNC
      SSAC=0.
      DO 157 I=1,NA
      DO 157 K=1,NC
  157 SSAC=SSAC+(TS(2,I,K)**2)/XNB
      SSBC=0.
      DO 158 J=1,NB
      DO 158 K=1,NC
  158 SSBC=SSBC+(TS(3,J,K)**2)/XNA
      WRITE(3,2048)SSG,SSSA,SSSB,SSSC,SSAB,SSAC,SSBC,ABC,SSWC,SSWP,SSCT,
     0SSWT
 2048 FORMAT(2X,'SSG=',F14.4,2X,'SSSA=',F14.4,2X,'SSSB=',F14.4,2X,'SSSC=
     0',F14.4/2X,'SSAB=',F14.4,2X,'SSAC=',F14.4,2X,'SSBC=',F14.4,2X,'ABC
     0=',F14.4/2X,'SSWC=',F14.4,2X,'SSWP=',F14.4,2X,'SSCT=',F14.4,2X,'SS
     0WT=',F14.4)
      SSBS=SSWP-SSG*XHN
      SSA=(SSSA-SSG)*XHN
      SSB=(SSSB-SSG)*XHN
      SAB=(SSAB-SSSA-SSSB+SSG)*XHN
      SSEB=SSWP-SSWT
      SSWS=SSWC-SSWP
      SSC=(SSSC-SSG)*XHN
      SAC=(SSAC-SSSA-SSSC+SSG)*XHN
      SBC=(SSBC-SSSB-SSSC+SSG)*XHN
      SABC=(ABC-SSAB-SSAC-SSBC+SSSA+SSSB+SSSC-SSG)*XHN
      SSEW=SSWC-SSWP-SSCT+SSWT
      DFBS=NT-1
      DFA=NA-1
      DFB=NB-1
      DFAB=(NA-1)*(NB-1)
      DFEB=NT-NA*NB
      DFWS=NT*(NC-1)
      DFC=NC-1
      DFAC=(NA-1)*(NC-1)
      DFBC=(NB-1)*(NC-1)
      DABC=(NA-1)*(NB-1)*(NC-1)
      DFEW=(NT-NA*NB)*(NC-1)
      XMSA=SSA/DFA
      XMSB=SSB/DFB
      XMAB=SAB/DFAB
      XMEB=SSEB/DFEB
      XMSC=SSC/DFC
      XMAC=SAC/DFAC
      XMBC=SBC/DFBC
      XABC=SABC/DABC
      XMEW=SSEW/DFEW
      FA=XMSA/XMEB
      FB=XMSB/XMEB
      FAB=XMAB/XMEB
      FC=XMSC/XMEW
```

```
      FAC=XMAC/XMEW
      FBC=XMBC/XMEW
      FABC=XABC/XMEW
      WRITE(3,2020)SSBS,DFBS,SSA,DFA,XMSA,FA,SSB,DFB,XMSB,FB,SAB,DFAB,
     QXMAB,FAB,SSEB,DFEB,XMEB,SSWS,DFWS,SSC,DFC,XMSC,FC,SAC,DFAC,XMAC,
     QFAC,SBC,DFBC,XMBC,FBC,SABC,DABC,XABC,FABC,SSEW,DFEW,XMEW
 2020 FORMAT(2X,'BETWEEN SUBJECTS',2(2X,F14.4)/4X,'TREATMENT-A',3X,4(2X,
     QF14.4)/4X,'TREATMENT-B',3X,4(2X,F14.4)/4X,'INTERACTION-AB',2X,4(2X
     Q,F14.4)/4X,'SUBJECTS WITHIN GROUPS'/4X,'ERROR BETWEEN',3X,3(2X,F14
     Q.4)/2X,'WITHIN SUBJECTS',1X,2(2X,F14.4)/4X,'TREATMENT-C',3X,4(2X,F
     Q14.4)/4X,'INTERACTION-AC',2X,4(2X,F14.4)/4X,'INTERACTION-BC',2X,4(
     Q2X,F14.4)/4X,'INTERACTION-ABC',1X,4(2X,F14.4)/4X,'INTERACTION-C BY
     Q SUBJ W/GROUPS'/4X,'ERROR WITHIN',4X,3(2X,F14.4))
      RETURN
      END


      SUBROUTINE AOVV(XG,SSWC,XHN,NT)
C THREE FACTORIAL WITH REPEATED MEASURE ON THIRD FACTOR(TRIALS)
C UNEQUAL CELLS, UNWEIGHTED MEANS, FIXED FACTORS
      COMMON/FTEST/NA,NB,NC,NS(10,10),T(10,10,40)
      COMMON/AOV/SS(10,10,10),TA(10,10,10),TS(3,10,10),TAS(3,10),TP(20)
      XG=0.
      SSWC=0.
      NT=0
      XHN=0.
      DO 10 I=1,NA
      DO 10 J=1,NB
      KS=NS(I,J)
      XS=KS
      NT=NT+KS
      XHN=XHN+1./XS
      IR=0
      DO 7 K=1,NC
      TA(I,J,K)=0.
      SS(I,J,K)=0.
      DO 5 IS=1,KS
      IR=IR+1
      TA(I,J,K)=TA(I,J,K)+T(I,J,IR)
      SS(I,J,K)=SS(I,J,K)+T(I,J,IR)**2
    5 CONTINUE
      TA(I,J,K)=TA(I,J,K)/XS
      XG=XG+TA(I,J,K)
      SSWC=SSWC+SS(I,J,K)
    7 CONTINUE
   10 CONTINUE
      XN=NA*NB
      XHN=XN/XHN
      IA=1
      IB=1
      KS=NS(1,1)
      IR=0
      DO 12 IS=1,NT
      TP(IS)=0.
      IR=IR+1
      IF(IR.LE.KS)GOTO 11
      IR=1
      IB=IB+1
      KS=NS(IA,IB)
      IF(IB.LE.NB)GOTO 11
      IB=1
      IA=IA+1
      KS=NS(IA,IB)
```

```
      IF(IA.GT.NA)GOTO 14
   11 DO 12 K=1,NC
      IRR=IR+(K-1)*KS
      TP(IS)=TP(IS)+T(IA,IB,IRR)
   12 CONTINUE
   14 CONTINUE
      DO 15 I=1,NA
      DO 15 J=1,NB
      TS(1,I,J)=0.
      DO 15 K=1,NC
   15 TS(1,I,J)=TS(1,I,J)+TA(I,J,K)
      DO 16 I=1,NA
      DO 16 K=1,NC
      TS(2,I,K)=0.
      DO 16 J=1,NB
   16 TS(2,I,K)=TS(2,I,K)+TA(I,J,K)
      DO 17 J=1,NB
      DO 17 K=1,NC
      TS(3,J,K)=0.
      DO 17 I=1,NA
   17 TS(3,J,K)=TS(3,J,K)+TA(I,J,K)
      DO 18 I=1,NA
      TAS(1,I)=0.
      DO 18 J=1,NB
   18 TAS(1,I)=TAS(1,I)+TS(1,I,J)
      DO 19 J=1,NB
      TAS(2,J)=0.
      DO 19 K=1,NC
   19 TAS(2,J)=TAS(2,J)+TS(3,J,K)
      DO 20 K=1,NC
      TAS(3,K)=0.
      DO 20 I=1,NA
   20 TAS(3,K)=TAS(3,K)+TS(2,I,K)
      RETURN
      END
YES, READ DATA
YES, PRINT DATA
/ OBSCURED OPTICS FIELD TEST, OCT-NOV. 1976, MERDC SUPPORT
    7     6     3
    4
  CR    16.     34.     TR    17.     14.5   SQ    16.5    11.
  CR    16.5    13.     SQ    17.     11.    TR    16.     17.
  CR    17.5    33.5    SQ    17.     21.5   TR    16.5    22.5


    3     2     1     4
    4     2     1     3
    1     3     4     2


  1.0    0   .0
   935  1020  1025
        27.          16.          34.     CR  CR  CR
        55.          17.2         14.5    TR  TR  TR
        35.          16.3         10.5    SQ  SQ  SQ
        19.          16.5         13.     CR  CR  CR
        11.          17.          11.     SQ  SQ  SQ
         7.          16.5         16.5    TR  TR  TR
        59.          18.          34.     CR  CR  CR
         6.          17.5         21.5    SQ  SQ  SQ
         6.          17.          32.5    TR  TR  TR
```

1.1 U .0
935 1020 1025

10.	17.	14.	TR	TR	TR
12.	16.	34.	CR	CR	CR
12.	16.5	10.5	SQ	SQ	SQ
2.	16.5	13.	CR	CR	CR
2.	17.	11.	SQ	SQ	SQ
25.	16.	16.5	TR	TR	TR
3.	17.5	33.5	CR	CR	CR
1.	17.5	21.5	SQ	SQ	SQ
3.	16.5	22.5	TR	TR	TR

0.8 U .0
935 1020 1025

59.	16.	39.	CR	CR	CR
59.	17.	14.5	TR	TR	TR
40.	16.5	10.5	SQ	SQ	SQ
5.	16.5	13.	CR	CR	CR
5.	17.	11.5	SQ	SQ	SQ
8.	16.	16.5	TR	TR	TR
13.	17.5	33.5	CR	CR	CR
3.	17.	21.5	SQ	SQ	SQ
4.	16.5	22.5	TR	TR	TR

0.9 U .0
935 1020 1025

6.	16.	34.	CR	CR	CR
16.	17.	14.5	TR	TR	TR
7.	16.5	10.5	SQ	SQ	SQ
3.	16.5	13.	CR	CR	CR
7.	17.	11.	SQ	SQ	SQ
3.	16.	17.	TR	TR	TR
9.	17.5	34.	CR	CR	CR
2.	17.5	21.5	SQ	SQ	SQ
4.	16.5	22.5	TR	TR	TR

4

CR	15.9	34.	SQ	16.5	10.5	TR	16.7	14.5
CR	16.5	13.5	SQ	16.7	11.4	TR	15.7	-3.2
CR	17.1	34.	SQ	16.9	22.	TR	16.4	22.8
CR	16.2	12.	SQ	17.5	42.	TR	16.8	11.
CR	17.4	39.6	SQ	15.9	-4.	TR	16.9	20.5
CR	17.2	29.1	SQ	16.5	7.7	TR	16.2	41.1

1	4	2	3
3	4	1	2
1	2	4	3
3	1	2	4
1	4	2	3
3	2	4	1

0.8	A	1.			
900	1010	1045	1400	1440	1525
5.	16.5	14.5	TR	TR	TR
2.	16.4	10.5	SQ	SQ	SQ
5.	16.	34.	CR	CR	CR
2.	16.5	13.	CR	CR	CR
2.5	17.0	11.2	SQ	SQ	SQ
11.0	15.6	-3.2	TR	TR	TR
2.	16.2	23.	TR	TR	TR
1.	16.7	22.	SQ	SQ	SQ
4.	17.1	34.	CR	CR	CR
5.	17.5	42.2	SQ	SQ	SQ
11.	16.2	12.	CR	CR	CR
2.	16.7	10.5	TR	TR	TR
2.	16.7	20.5	TR	TR	TR
7.	17.2	39.9	CR	CR	CR
8.	15.9	-4.0	SQ	SQ	SQ
7.	16.	41.	TR	TR	TR
4.	16.5	7.9	SQ	SQ	SQ
18.	16.9	30.2	CR	CR	CR
1.1	G	1.			
917	1016	1050	1350	1455	1520
7.5	14.8	13.5	TR	TR	TR
2.0	15.5	10.5	SQ	SQ	SQ
4.8	15.5	33.5	CR	CR	CR
6.0	16.5	13.5	CR	CR	CR
3.4	16.6	11.4	SQ	SQ	SQ
4.7	15.4	-3.5	TR	TR	TR
3.0	16.2	22.8	TR	TR	TR
3.0	16.8	21.8	SQ	SQ	SQ
17.0	17.2	34.	CR	CR	CR
61.					
61.					
61.					
61.					
61.					
61.					
61.					
61.					
61.					
1.0	B	1.			
910	955	1055	1355	1445	1530
19.	16.	34.7	CR	CR	CR
13.	16.7	14.2	TR	TR	TR

```
       5.          16.5          10.5    SQ   SQ   SQ
      11.7         16.5          13.25   CR   CR   CR
       4.2         17.0          11.0    SQ   SQ   SQ
       5.0         15.6          -3.5    TR   TR   TR
       3.0         16.4          22.8    TR   TR   TR
       2.0         16.7          21.8    SQ   SQ   SQ
       7.0         17.3          34.     CR   CR   CR
      29.0         16.5          22.5    SQ   SQ   BS
      61.0
      61.0
      45.0         15.7          -4.0    CR   CR   SQ
      61.0
      61.0
       9.0         16.1          41.     TR   TR   TR
      61.
      61.
0.8   C   1.
915   1005    1055   1410   1450   1515
       9.          15.9          33.5    CR   CR   CR
       4.          16.2          10.3    SQ   SQ   SQ
       6.4         16.4          14.5    TR   TR   TR
       9.          16.5          13.     CR   CR   CR
       4.          17.           11.2    SQ   SQ   SQ
       6.4         15.5          -3.2    TR   TR   TR
       3.          16.4          22.8    TR   TR   TR
       2.          16.7          21.8    SQ   SQ   SQ
       4.          17.2          34.     CR   CR   CR
      27.          17.           12.     SQ   SQ   CR
       6.          16.7          10.7    TR   TR   TR
      61.
       5.          16.8          20.5    TR   TR   TR
      35.          16.3           9.5    SQ   SQ   BS
      15.          15.6          -4.     SQ   SQ   SQ
      29.          16.2          41.     TR   TR   TR
      15.          17.2          30.2    SQ   SQ   CR
      32.          16.6           7.9    CR   CR   SQ
 2
CR    16.     33.7   SQ   16.3    10.5   TR    16.7    14.4
CR    16.4    13.2   SQ   16.9    11.3   TR    15.7    -3.2
CR    17.2    33.8   SQ   16.9    21.9   TR    16.4    22.8
CR    16.2    12.    SQ   17.5    42.    TR    16.8    11.0
CR    17.4    39.6   SQ   15.8    -4.1   TR    16.8    20.5
CR    17.2    29.1   SQ   16.5     7.7   TR    16.2    41.1
 1     2
 2     1
 1     2
 2     1
 1     2
 1     2
1.1   A   1.
920   1014    1040   1405   1440   1525
       4.          16.2          10.5    SQ   SQ   SQ
      22.          16.7          14.5    TR   TR   TR
      10.          16.           33.5    CR   CR   CR
       4.          16.4          13.2    CR   CR   CR
       2.          16.8          11.3    SQ   SQ   SQ
      21.          15.8          -3.4    TR   TR   TR
       3.          16.5          22.8    TR   TR   TR
       1.          16.9          22.     SQ   SQ   SQ
       4.          17.2          34.     CR   CR   CR
      10.          16.7          10.5    TR   TR   TR
      61.
      61.
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      18.          15.8         -4.1   SQ   SQ   SQ
      10.          16.8         20.5   TR   TR   TR
      56.          17.3         39.6   CR   CR   CR
       5.          16.2          7.7   SQ   SQ   SQ
      14.          17.0         30.    CR   CR   CR
       9.          16.2         41.    TR   TR   TR
 1.2   C  1.
 930  1005  1055  1400  1445  1530
       7.          16.8         14.6   TR   TR   TR
       3.          16.4         10.5   SQ   SQ   SQ
      29.          16.          33.7   CR   CR   CR
      36.          16.5         13.2   CR   CR   CR
       3.          16.4         11.2   SQ   SQ   SQ
       9.          15.6         -3.4   TR   TR   TR
       7.          16.2         22.7   TR   TR   TR
       1.          16.8         21.9   SQ   SQ   SQ
       2.          17.2         33.9   CR   CR   CR
      30.          16.5         10.6   SQ   SQ   TR
      61.
      61.
       8.          15.8         -4.0   SQ   SQ   SQ
      42.          16.7         20.6   TR   TR   TR
      37.          16.3          9.6   CR   CR   BS
      29.          16.2         41.    TR   TR   TR
      59.          16.5          7.7   CR   CR   SQ
      61.
  4
CR    16.    33.6   SQ   16.4   10.5   TR   16.8   14.3
CR    16.5   13.1   SQ   17.0   11.1   TR   15.5   -3.1
CR    17.3   33.8   SQ   16.6   21.5   TR   16.3   22.7
CR    15.3   12.0   SQ   17.7   42.2   TR   16.7   10.7
CR    17.4   39.6   SQ   15.9   -4.3   TR   16.9   20.5
CR    17.3   30.1   SQ   16.5    7.6   TR   16.4   41.1
  1    4      2      3
  3    4      1      2
  1    2      4      3
  3    1      2      4
  1    4      2      3
  3    2      4      1
 1.1   A  1.
 930  1017  1042  1340  1420  1515
      4.3          16.          33.    CR   CR   CR
     11.5          16.5         10.3   SQ   SQ   SQ
      2.3          16.9         14.1   TR   TR   TR
      3.0          16.5         13.1   CR   CR   CR
      1.6          16.9         11.1   SQ   SQ   SQ
     11.1          15.5         -3.1   TR   TR   TR
      2.7          16.4         22.5   TR   TR   TR
      1.2          16.9         21.4   SQ   SQ   SQ
      2.7          17.4         33.7   CR   CR   CR
      3.4          16.2         12.0   CR   CR   CR
      5.8          16.8         10.6   TR   TR   TR
     22.6          17.5         42.1   SQ   SQ   SQ
      1.6          16.0         -4.4   SQ   SQ   SQ
      4.1          16.5         20.3   TR   TR   TR
      3.8          17.5         39.5   CR   CR   CR
      2.9          16.7          7.6   SQ   SQ   SQ
      4.2          17.2         30.0   CR   CR   CR
      2.4          16.5         41.0   TR   TR   TR
 1.0   C  1.
 949  1020  1047  1325  1435  1511
      4.2          16.          33.6   CR   CR   CR
      4.9          16.4         10.7   SQ   SQ   SQ
```

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        2.3        16.8          14.2   TR   TR   TR
        3.2        16.5          13.1   CR   CR   CR
        6.2        15.6          -3.1   TR   TR   TR
       45.6        16.9          11.2   SQ   SQ   SQ
        2.5        17.0          21.5   SQ   SQ   SQ
       12.8        17.0          34.3   CR   CR   CR
        1.7        16.4          27.6   TR   TR   TR
        4.6        16.5          10.6   SQ   SQ   TR
        1.0        16.4          12.    CR   CR   CR
       13.7        15.9          15.7   TR   TR   BS
        2.5        15.9          -4.0   SQ   SQ   SQ
        6.7        16.6          20.4   TR   TR   TR
       55.6        17.3          39.6   CR   CR   CR
       10.9        16.5           8.0   SQ   SQ   SQ
       17.4        16.4           9.5   TR   TR   BS
       17.2        16.5           8.0   CR   CR   SQ
1.0     B   1.
 937   1010   1058   1333   1425   1530
        3.4        16.7          14.3   TR   TR   TR
        1.5        16.5          10.5   SQ   SQ   SQ
        2.8        16.0          33.2   CR   CR   CR
        1.2        16.5          13.0   CR   CR   CR
        1.0        16.8          11.2   SQ   SQ   SQ
       12.5        15.7          -3.1   TR   TR   TR
        2.0        16.9          21.6   SQ   SQ   SQ
        0.6        16.3          22.6   TR   TR   TR
        1.5        17.5          33.9   CR   CR   CR
        3.4        16.0          12.0   SQ   SQ   CR
       14.2        16.5          19.1   SQ   SQ   BS
       33.0        16.5          22.2   TR   TR   BS
        3.3        16.0          -4.    SQ   SQ   SQ
       11.6        17.0          19.    TR   TR   BS
        2.9        15.6          22.1   CR   CR   BS
       41.6        16.0          41.    TR   TR   TR
       18.6        16.5          22.    CR   CR   BS
       33.2        16.5          15.3   SQ   SQ   BS
 .8     G   1.
 942   1014   1053   1345   1433   1506
        3.6        16.5          10.5   SQ   SQ   SQ
        7.1        16.0          33.5   CR   CR   CR
       21.8        16.7          14.3   TR   TR   TR
        3.8        16.5          13.1   CR   CR   CR
        2.4        16.9          11.2   SQ   SQ   SQ
        4.8        15.5          -3.1   TR   TR   TR
        2.5        17.           21.5   SQ   SQ   SQ
        1.4        16.4          22.9   TR   TR   TR
        2.5        17.4          33.9   CR   CR   CR
       61.
       61.
       61.
       61.
       61.
       61.
       61.
       61.
       61.
  4
CR     16.     33.2   SQ    16.4    10.5   TR    16.7    14.2
CR     16.5    13.    SQ    16.9    11.2   TR    15.6    16.6
CR     17.2    33.7   SQ    16.9    21.7   TR    16.4    22.7
CR     16.3    12.    SQ    17.6    42.1   TR    16.6    10.6
CR     17.2    39.6   SQ    15.6    -4.2   TR    16.9    20.4
CR     17.1    30.    SQ    16.5     7.8   TR    16.2    40.6
```

1	2	4	3					
3	4	1	2					
4	3	2	1					
3	1	2	4					
1	4	2	3					
3	2	4	1					
.9	B	1.						
930	1020	1115	1407	1435	1520			
	9.2		15.8		33.4	CR	CR	CR
	12.6		16.7		14.2	TR	TR	TR
	2.4		16.4		10.5	SQ	SQ	SQ
	19.5		16.8		11.0	SQ	SQ	SQ
	1.6		16.7		13.0	CR	CR	CR
	4.2		15.6		-3.4	TR	TR	TR
	4.8		16.6		21.5	SQ	SQ	SQ
	1.2		16.4		22.6	TR	TR	TR
	9.0		17.0		33.8	CR	CR	CR
	38.0		16.2		12.3	CR	CR	CR
	6.2		16.3		22.6	TR	TR	BS
	61.							
	31.2		14.4		17.	CR	CR	BS
	25.		16.3		22.5	CR	CR	BS
	61.							
	61.							
	61.							
	61.							
1.0	A	1.						
935	1030	1110	1350	1450	1515			
	18.6		15.8		33.3	CR	CR	CR
	10.2		16.7		14.3	TR	TR	TR
	2.1		16.3		10.4	SQ	SQ	SQ
	19.6		16.5		13.1	CR	CR	CR
	1.6		16.8		11.1	SQ	SQ	SQ
	3.0		15.7		-3.3	TR	TR	TR
	2.6		16.4		22.6	TR	TR	TR
	1.8		16.8		21.6	SQ	SQ	SQ
	4.0		17.2		33.8	CR	CR	CR
	20.4		16.2		12.2	CR	CR	CR
	2.4		16.7		10.6	TR	TR	TR
	54.2		17.6		42.1	SQ	SQ	SQ
	4.1		16.9		20.4	TR	TR	TR
	8.0		17.3		39.5	CR	CR	CR
	19.4		15.9		-4.2	SQ	SQ	SQ
	9.8		16.2		40.6	TR	TR	TR
	18.		16.4		7.6	SQ	SQ	SQ
	39.7		17.2		30.1	CR	CR	CR
1.2	B	1.						
945	1005	1105	1400	1440	1525			
	4.		16.4		14.2	TR	TR	TR
	2.		16.4		10.5	SQ	SQ	SQ
	8.8		16.1		33.3	CR	CR	CR
	1.4		16.5		13.1	CR	CR	CR
	1.0		16.9		11.2	SQ	SQ	SQ
	10.5		15.7		-3.4	TR	TR	TR
	2.4		16.2		22.6	TR	TR	TR
	1.7		16.7		21.6	SQ	SQ	SQ
	8.1		17.		33.8	CR	CR	CR
	22.2		16.2		22.4	SQ	BS	BS
	61.							
	61.							
	17.6		15.5		-4.	CR	CR	SQ
	61.							
	61.							

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      61.
      61.
      61.
1.0    0   1.0
 940  1010  1100  1415  1445  1510
      23.6        16.3        10.4   SQ  SQ  SQ
      21.         16.         33.2   CR  CR  CR
       5.4        16.6        14.4   TR  TR  TR
       5.4        16.5        13.1   CR  CR  CR
       1.6        16.6        11.1   SQ  SQ  SQ
      17.         15.6        -3.4   TR  TR  TR
       3.1        16.3        22.6   TR  TR  TR
       1.6        16.7        21.6   SQ  SQ  SQ
       2.9        16.9        33.8   CR  CR  CR
      27.4        16.3        12.    SQ  SQ  CR
       8.         16.9        14.6   CR  CR  BS
      61.
      25.8        16.         -4.1   SQ  SQ  SQ
      53.         16.9        20.4   CR  CR  TR
      13.2        16.1        15.5   CR  CR  BS
      24.1        16.3        40.6   TR  TR  TR
      61.
      61.
 4
CR    16.    33.5  SQ   16.3   10.2   TR   16.6   14.1
CR    15.5   16.4  SQ   16.9   11.2   TR   16.5   13.
CR    15.5   16.4  SQ   16.9   11.2   TR   16.9   13.
CR    16.4   11.9  SQ   17.5   42.    TR   16.7   10.5
CR    17.3   39.6  SQ   15.8   15.7   TR   16.8   20.5
CR    17.1   30.   SQ   16.4    7.4   TR   16.1   40.8
 1     2     4     3
 3     4     1     2
 3     4     1     2
 3     1     2     4
 1     4     2     3
 3     2     4     1
1.2    8   .8
1100  1300  1300  1345  1400  1450
       4.         15.5        14.1   TR  TR  TR
       2.         15.5        10.2   SQ  SQ  SQ
       9.         15.5        33.4   CR  CR  CR
       4.         16.5        13.    TR  TR  TR
       2.         16.8        11.1   SQ  SQ  SQ
      12.         15.6        16.2   CR  CR  CR
       4.         16.5        13.    TR  TR  TR
       2.         16.8        11.1   SQ  SQ  SQ
      12.         15.6        16.2   CR  CR  CR
       3.8        16.2        11.9   CR  CR  CR
       2.6        16.4        10.6   TR  TR  TR
      29.         17.4        42.    SQ  SQ  SQ
       3.8        16.6        20.6   TR  TR  TR
      15.         17.1        39.4   CR  CR  CR
      59.         15.6        15.7   SQ  SQ  SQ
       6.4        16.3         7.7   SQ  SQ  SQ
      15.2        17.         30.    CR  CR  CR
       3.8        16.1        40.6   TR  TR  TR
1.0    0   .8
1105  1310  1310  1335  1415  1440
       5.         16.2        10.1   SQ  SQ  SQ
       1.         15.4        14.1   TR  TR  TR
       9.6        16.         33.5   CR  CR  CR
       3.         16.4        13.    TR  TR  TR
       1.         16.8        11.2   SQ  SQ  SQ
```

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      8.        15.7        16.3     CR   CR   CR
      3.        16.4        13.      TR   TR   TR
      1.        16.8        11.2     SQ   SQ   SQ
      8.        15.7        16.3     CR   CR   CR
     59.        15.7        10.6     TR   TR   TR
     61.
     61.
     61.
     61.
     61.
      7.0       16.5         7.6     SQ   SQ   SQ
     61.
     61.
0.9   G   .3
1115  1245  1245  1340  1405  1510
     11.        16.1        10.2     SQ   SQ   SQ
      1.6       16.4        14.      TR   TR   TR
      3.        16.         33.5     CR   CR   CR
      2.        16.2        13.      TR   TR   TR
      2.        16.2        11.2     SQ   SQ   SQ
      2.        15.7        15.7     CR   CR   CR
      2.        16.2        13.      TR   TR   TR
      2.        16.2        11.2     SQ   SQ   SQ
      2.        15.7        15.7     CR   CR   CR
      3.        16.3        11.9     CR   CR   CR
      3.        16.5        10.6     TR   TR   TR
     17.2       17.1        42.0     SQ   SQ   SQ
      2.0       16.8        20.6     TR   TR   TR
      3.4       15.6        15.6     SQ   SQ   SQ
      6.4       17.2        39.6     CR   CR   CR
      2.2       16.9        30.      CR   CR   CR
      2.1       16.2        40.6     TR   TR   TR
      4.2       16.4         7.7     SQ   SQ   SQ
0.9   B   .3
1110  1250  1250  1350  1410  1430
      2.4       16.2        14.1     TR   TR   TR
      2.2       16.4        10.2     SQ   SQ   SQ
     11.        16.         33.5     CR   CR   CR
      6.        16.2        13.      TR   TR   TR
      2.6       16.7        11.2     SQ   SQ   SQ
      7.0       15.6        16.3     CR   CR   CR
      6.        16.2        13.      TR   TR   TR
      2.6       16.7        11.2     SQ   SQ   SQ
      7.0       15.6        16.3     CR   CR   CR
      5.        16.2        11.9     CR   CR   CR
      2.6       16.5        10.5     TR   TR   TR
     26.7       17.4        42.      SQ   SQ   SQ
      2.        16.9        20.6     TR   TR   TR
      3.8       17.1        39.5     CR   CR   CR
      8.2       15.6        15.7     SQ   SQ   SQ
     11.6       16.1        40.8     TR   TR   TR
      8.6       17.0        30.0     CR   CR   CR
      8.2       16.4         8.7     SQ   SQ   SQ
  4
CR   15.9   33.7  SQ   16.3   10.3  TR   16.8   14.2
CR   16.5   12.9  SQ   16.9   11.0  TR   15.6   16.6
CR   17.1   33.9  SQ   16.8   21.6  TR   16.2   22.6
CR   16.1   12.1  SQ   17.4   42.2  TR   16.7   10.6
CR   17.3   39.5  SQ   15.8   -4.3  TR   16.9   20.4
CR   17.0   30.1  SQ   16.5    7.7  TR   16.2   40.9
  1    2    4    3
  3    4    1    2
  4    3    2    1
  3    1    2    4
```

1	4	2	3					
3	2	4	1					
.9	G	.8						
930	1015	1040	1310	1405	1450			
	2.		16.5		14.1	TR	TR	TR
	2.		16.2		10.1	SQ	SQ	SQ
	9.8		15.7		33.6	CR	CR	CR
	1.2		16.5		13.0	CR	CR	CR
	1.2		16.8		11.	SQ	SQ	SQ
	2.6		15.6		16.6	TR	TR	TR
	2.4		16.2		22.7	TR	TR	TR
	0.8		16.7		21.7	SQ	SQ	SQ
	5.0		16.9		33.9	CR	CR	CR
	26.		16.4		10.6	TR	TR	TR
	52.		16.3		12.0	CR	CR	CR
	61.							
	37.5		16.4		20.4	TR	TR	TR
	61.							
	61.							
	57.		16.2		7.9	SQ	SQ	SQ
	61.							
	61.							
.8	B	.6						
935	1017	1037	1300	1420	1445			
	6.		16.6		14.2	TR	TR	TR
	1.		16.2		10.2	SQ	SQ	SQ
	7.5		15.9		33.7	CR	CR	CR
	4.		16.5		13.	CR	CR	CR
	1.		16.9		11.1	SQ	SQ	SQ
	8.2		15.6		16.7	TR	TR	TR
	1.4		16.3		22.7	TR	TR	TR
	.8		16.6		21.6	SQ	SQ	SQ
	18.4		17.0		33.9	CR	CR	CR
	5.		16.2		12.	CR	CR	CR
	1.		16.4		10.6	TR	TR	TR
	28.		17.2		42.1	SQ	SQ	SQ
	1.6		16.5		20.3	TR	TR	TR
	9.2		17.2		39.4	CR	CR	CR
	11.		16.		-4.2	SQ	SQ	SQ
	7.		16.5		7.6	SQ	SQ	SQ
	13.6		16.9		30.1	CR	CR	CR
	7.6		16.2		40.9	TR	TR	TR
1.1	B	.3						
945	1005	1036	1305	1410	1455			
	1.		16.7		14.1	TR	TR	TR
	2.8		16.3		10.3	SQ	SQ	SQ
	12.		16.		33.7	CR	CR	CR
	1.8		16.5		13.	CR	CR	CR
	2.		16.9		11.1	SQ	SQ	SQ
	8.		15.7		16.6	TR	TR	TR
	2.2		16.2		22.6	TR	TR	TR
	2.0		16.6		21.6	SQ	SQ	SQ
	2.8		17.1		33.9	CR	CR	CR
	11.6		16.3		12.	CR	CR	CR
	1.1		16.4		10.6	TR	TR	TR
	21.		17.5		42.1	SQ	SQ	SQ
	2.		16.8		20.6	TR	TR	TR
	7.4		17.2		39.6	CR	CR	CR
	11.2		15.8		-4.2	SQ	SQ	SQ
	6.8		17.		30.1	CR	CR	CR
	5.4		16.1		40.9	TR	TR	TR
	9.6		16.5		7.8	SQ	SQ	SQ

1.2 G .3

940	1010	1035	1315	1415	1440			
	1.		16.7		14.2	TR	TR	TR
	3.		16.2		10.2	SQ	SQ	SQ
	4.8		15.9		33.7	CR	CR	CR
	2.0		16.4		13.	CR	CR	CR
	1.		16.9		11.1	SQ	SQ	SQ
	2.4		15.6		16.6	TR	TR	TR
	1.		16.3		22.4	TR	TR	TR
	0.2		16.7		21.7	SQ	SQ	SQ
	2.0		17.0		33.9	CR	CR	CR
	10.		16.2		12.	CR	CR	CR
	1.		16.5		10.6	TR	TR	TR
	16.		17.5		42.1	SQ	SQ	SQ
	2.6		16.8		20.5	TR	TR	TR
	6.6		15.8		-4.3	SQ	SQ	SQ
	8.8		17.2		39.6	CR	CR	CR
	5.0		17.0		30.1	CR	CR	CR
	6.		16.2		40.9	TR	TR	TR
	16.2		16.4		7.9	SQ	SQ	SQ