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SSD Simulator Validation
by
Gemini Visual Acuity Experiment

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ABSTRACT

A test to determine if proper contrast levels were being used in the SSD simulator was performed, based on the Gemini program visual acuity test. Due to the limited number of trials no statistically useful information was obtained and therefore validation of simulator contrast levels was not possible.

I. OBJECTIVE

To compare visual acuity in space with that obtained on the SSD simulator for the purpose of validating that simulator contrast levels are appropriate.

II. BACKGROUND

The SSD simulator uses a flooding light to decrease the contrast of the photographic materials used. The intensity of flood illumination used has been determined through computations based on measurements of edge targets and the use of a model atmosphere. It has been requested that this approach be validated by a limited experimental activity. The Gemini viewing experiment, which was suggested by Dr. Duntley of the Visibility Laboratory, is an attempt to provide such a validation.

III. EXPERIMENT CONCEPT

The Gemini program had a visual acuity experiment whose primary objectives were to determine:

1. the effect of the space environment on visual acuity
2. visual acuity from space against ground objects

Visual acuity was measured by testing the astronauts against a field of decreasing length rectangular bars displayed in various orientations. The astronauts were tested both on the ground and in space and it was determined that no change in visual acuity occurred as a result of being in the space environment. To evaluate the second objective the astronauts viewed a ground representation of the test field constructed near Larado, Texas (another field was constructed near Carnevon, Australia, but never used). The astronaut scores on this test indicated that there was no reason not to believe that visual acuity from space against ground objects could not be predicted through ground testing, if properly simulated viewing conditions were provided. It should therefore be possible to determine if proper viewing conditions are being simulated at SSD by testing one of the astronauts against the bar target field as viewed through the SSD simulator. If his scores on this test are within his predicted performance envelope, there should be no reason for not believing that the SSD simulator is providing proper viewing and contrast conditions.

IV. EXPERIMENTAL PROCEDURES AND EQUIPMENT

A. Subject

We would have wished to test Gemini astronaut Borman, who made the visual report on the Larado field in Gemini 7, but he was not available. We were able however, to use R. L. Stapleford of Visibility Laboratory for whom ground test data and therefore predicted performance curves were available.

B. Material

From aircraft photographs of the Larado site the Visibility Laboratory made eight slides, each with a field of eight bar targets. One set of four slides had a higher contrast than the other set. This document reports on test results using the low-contrast slides only. A diagram of a typical slide with the orientation and bar number convention used is shown in Figure 1.

C. Simulator Setup

Nominally, the SSD simulator has a magnification of 7.5x which can be step changed to 15x. However, even at 7.5x, the required slide dimensions to insure that the proper scene scale was provided at the eye were too small to permit slide manufacture. The simulator eyepiece was therefore changed to provide only 1.5x and the test was run at this magnification. A biocular eyepiece was used throughout the test.

D. Test Conditions

1.) Two flood illumination conditions were run, namely 22 and 78.5 foot-lamberts as measured through the left eyepiece with the table light off. The first level corresponds to the estimated setting needed to provide proper contrast levels and has been used throughout our previous tests.

2.) The table illumination was measured as 300 foot-lamberts through the left eyepiece and 140 foot-lamberts through the right eyepiece.

3.) The estimated transmission of the slide background is 5%. This estimate was obtained by measuring the table illumination coming through the left eyepiece, with the slide in place and with the slide removed.

4.) The subject was allowed a thirty-second response time for each slide. (For most slides, the subject required less than 15 seconds to respond.)

E. Test Procedures

All slides were run at a single floodlight setting, and then the flood setting was changed and the slides were run again. The set of low contrast slides were run first, and then the high contrast set.

V DATA ANALYSIS AND REDUCTION

A. Bar Contrast and Area

Previous ground tests from which the subject's performance envelope was determined were run against bars whose length was four times their width. When the Larado field was constructed, it was determined that if 4/1 bars were used, the contrast at the astronaut's eye in the spacecraft would be much greater than tested on the ground. Since the bar width was not resolvable from space, it was decided to decrease the width of the Larado bars and thereby decrease the apparent contrast of the bars as viewed by the astronaut from space. Table I compares the Larado bars with 4/1 bars.

If densitometer measurements are made of the slides used in the SSD test, the total illuminance of each bar can be determined. Unfortunately, blow-ups of the slides show that the bars are not neat rectangles, but somewhat irregular ellipses. If it is assumed that the eye will see these ellipses as bars of the proper length, but unresolvable in width, then the total illuminance can be assumed to emanate from the actual rectangular Larado bar. Under this assumption, the average film contrast of the bars on the low contrast slide is 7.16. When these bars are viewed in the simulator, the eye "spreads" the bar width so that the bar area "looks" larger than it is, and in fact looks like a 4/1 bar at reduced contrast. The reduction in contrast is the ratio of the actual bar width to the width required to produce a 4/1 bar. Column 6 of Table I shows the contrast at the eye for each bar as viewed through the simulator with no flood illumination.

The contrast at the eye with flood illumination can be computed for any bar as,

$$C = \frac{Q(B_o) - B_o}{B_o + B_f}$$

where Q = Bar contrast with no flood illumination

B_o = Background illumination (15 ft-lamberts for the left eyepiece)

B_f = Flood illumination

The contrast values for each bar for the two flood settings are shown in Columns 7 and 8 of Table I.

B. SCORING

To be compatible with the predicted performance data, we wish to determine from the raw data the bar at which, with high confidence, the probability of correctly determining bar orientation is .5.

Table II shows the corrected scores for each bar. The correction, which deweights the extremes, is computed from

$$\text{Corrected Mean} = \frac{X - 25}{100 - 25}$$

where X = the raw score mean

If the data were Gaussian, a least squares straight line approximation should very nearly fit a cumulative probability curve based on the corrected data. It is apparent from Table II that a least squares straight line is a poor fit to the data, and therefore the scoring results are not Gaussian.

This result is undoubtedly due to the limited number of trials on each bar (4). A chi-square test was run which indicates the deviations of scores are not statistically significant--a result which is again due to the limited sample size.

VI RESULTS AND CONCLUSIONS

Figure 2 shows the contrast at the eye of the bars as a function of bar area for each of the floodlight settings used. In addition, the estimated bar contrast at the eye of Astronaut Borman during the Gemini overflight of the Larado site is also shown. It can be seen that the 22 foot-lambert flood setting, which has been used throughout our previous tests, happens to match the estimated bar contrast as viewed from space during the Gemini Test. If the slide and the material we have used previously were processed identically, we could conclude that this flood setting was not unreasonable for use.

Statistically significant scores were not obtained, and therefore we cannot judge from this test the validity of the simulated contrast levels being used in the SSD simulator.

DISTRIBUTION

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FIGURE 1

TYPICAL SLIDE

BAR NUMBERS

1	2	3	4
5	6	7	8

ORIENTATION CONVENTION

| = 1
/ = 2
— = 3
\ = 4

TABLE I

TEST INFORMATION
(LOW-CONTRAST SLIDES)

BAR NO.	LARADO BAR LENGTH (FEET)	LARADO BAR WIDTH (FEET)	WIDTH FOR 4/1 BAR (FEET)	EQUIV. SUBTENSE (MIN^2)	CONTRAST WITH $B_f = 0$	CONTRAST WITH $B_f = 22$ FT-LAMBERTS	CONTRAST WITH $B_f = 78.5$ FT-LAMBERTS
1	608	26	152	1.75	1.22	.485	.194
2	496	25	124	1.16	1.44	.572	.228
3	408	24	102	.787	1.68	.667	.266
4	336	24	84	.534	1.99	.792	.315
5	272	23	68	.349	2.41	.960	.382
6	224	22	56	.237	2.80	1.116	.444
7	184	22	46	.160	3.41	1.358	.540
8	152	22	38	.1092	4.13	1.644	.654

TABLE II

CORRECTED SCORES

B_f = 22 FOOT-LAMBERTS		B_f = 78.5 FOOT-LAMBERTS	
BAR	SCORE (%)	BAR	SCORE (%)
1	100	1	100
2	100	2	66.7
3	100	3	66.7
4	66.7	4	33.3
5	66.7	5	66.7
6	33.3	6	66.7
7	66.7	7	0
8	0	8	0

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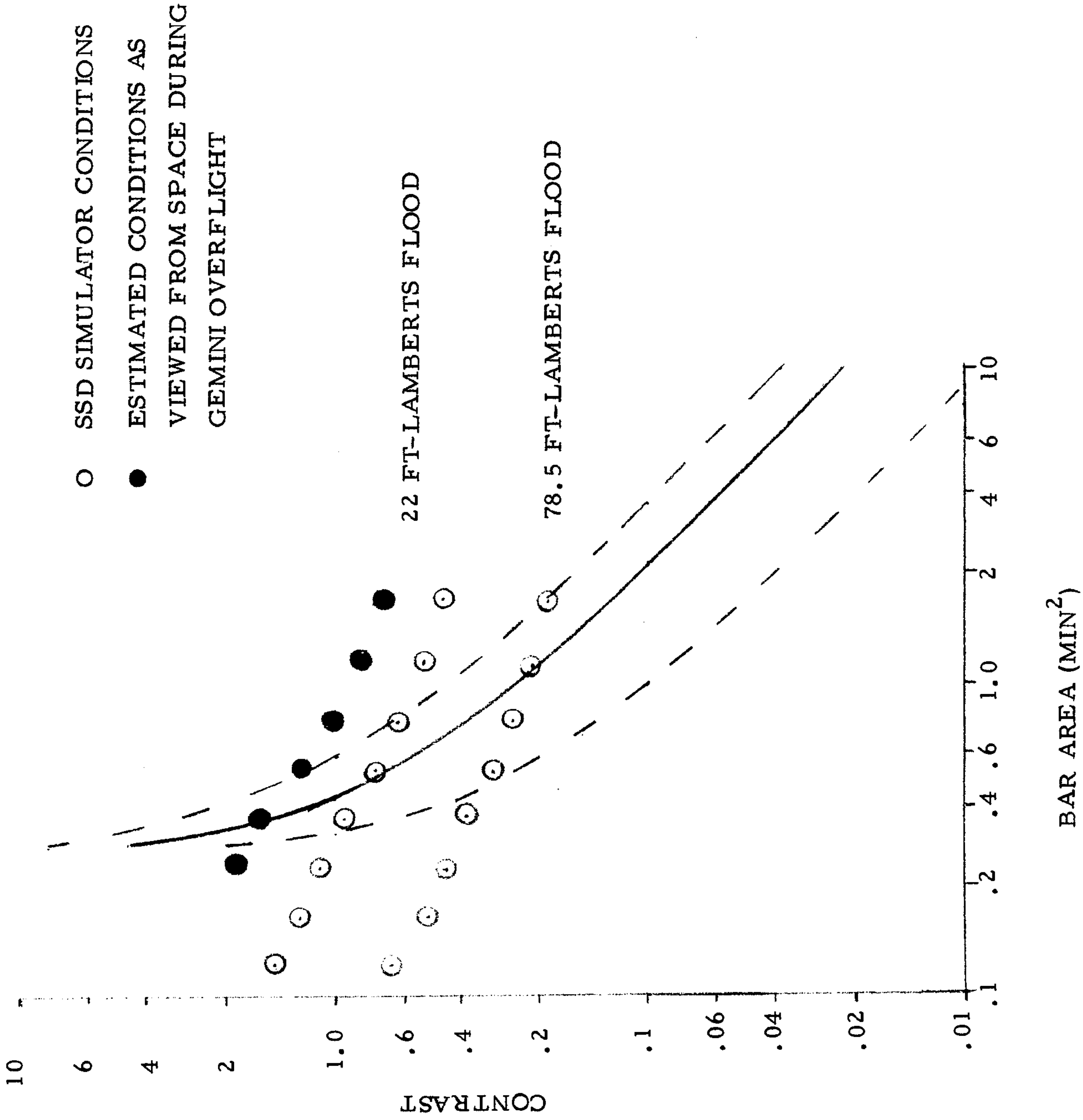
FIGURE 2

CONTRAST VS. BAR AREA



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