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SECRET

THE EFFECTS OF PHOTOGRAPHIC GROUND RESOLUTION ON PHOTO INTERPRETATION

FINAL REPORT

25X1

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THE EFFECTS OF PHOTOGRAPHIC GROUND RESOLUTION ON PHOTO INTERPRETATION

Final Report

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INTRODUCTION

This contract was a continuation of an effort to determine the effects of photographic ground resolution on the accuracy of the information produced by photo interpreters (PIs). Three comprehensive studies had been done under a previous contract [redacted] In the first, the targets were U. S. aircraft; in the second, they were domestic ICBM sites; and in the third, they were scale models of mobile foreign radars. Technical reports describing these studies have been submitted to the sponsor. 25X1

The studies showed clearly that the effects of ground resolution on photographic interpretation are target specific; one class of targets requires better resolution than another class for complete exploitation.

It had been suggested that ground forces as a class of targets might require even better ground resolutions than radars for the complete exploitation of photography. Therefore, it was proposed that additional studies similar to the aircraft, missile, and radar studies be conducted with ground equipment as the targets; more specifically, it was proposed that two studies be done in the following two phases:

Phase I - Model Study and Preparation for the Field Study

1a: A study of the effects of ground resolution on the identification of military vehicles using

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scale models as targets (the "model" study).

1b: The preparation of materials for a study of the effects of ground resolution on the interpretation of ground forces using real ground force equipment and personnel as targets (the "field" study).

Phase II - Execution of the Field Study

The proposal, which was to conduct Phase I only, was supported and a new contract was written. The starting date was 5 June 1969, and the termination date (after an extension in time without additional funds) was 15 July 1970.

WORK STATEMENT

In Phase Ia, the model study, the following tasks were to have been performed:

Task 1. Preparation of photographic stimulus materials.

Task 2. Development of the experimental design, instructions, and PI response recording method.

Task 3. Selection of experimental subjects and collection of experimental data.

Task 4. Analysis of data.

Task 5. Preparation of the technical report and briefings.

In Phase Ib, preparation for the field study, the following tasks were to have been performed:

Task 1. Selection and procurement of the required aircraft and camera.

Task 2. Selection, procurement, and placement of appropriate targets.

Task 3. Construction or procurement and placement of test targets.

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Task 4. Collection of "ground truth" information.

Task 5. Collection of photography.

WORK PERFORMED

The model study, Phase Ia, was completed, several briefings were given in Washington, and the technical report was published in October 1969. The work is described in:

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The model study was the first effort to determine the relation between line-scan and photographic images in terms of photo interpreter target identification performance. Two line-scan image variables were investigated: signal-to-noise ratio and number of scans per target. One photographic image variable was investigated: ground resolution. The targets were models of tanks and miscellaneous vehicles, and the subjects were 50 professional photo interpreters. The data were analyzed to determine what combinations of the two line-scan variables were equivalent to photographic ground resolution in terms of percent correct target identification.

The results with the two types of imagery and the relations between the results should be valuable to system designers. However, additional research on line-scan imagery should be done.

Phase Ib was also completed. The photographic acquisition requirements established jointly by the sponsor, Autometric/Raytheon, and were:

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1. One-inch ground resolution as determined from one cycle on a bar target.

2. Stereo availability; 20% convergence angle or 60% overlap.

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3. A frame camera flown in a vertical position; conventional black-and-white film.

4. Little haze, minimum cloud cover, and a sum angle of about 60° above the horizon.

5. Original negative processed with a density wedge.

An investigation was made of the camera/vehicle systems that could fulfill the requirements. Few were in existence but an adequate one was obtained through the sponsor.

Arrangements were made with Aberdeen Proving Ground to photograph the vehicles and weapons in the museum and other ground order-of-battle targets. Also, permission was obtained to place test targets on the ground to obtain "ground truth" data, photographs, and measurements. These tasks were performed.

Several flights were flown to determine the appropriate altitude and camera settings. Many delays due to equipment malfunctions, camera and processing problems, and weather were encountered.

On 17 September 1969, the acquisition flight was flown over the museum at Aberdeen. An effort was made to get all of the targets on one or two frames. From three-bar target estimates, the ground resolution of the photography was approximately 1.5".

Second generation paper prints of the Aberdeen museum targets are shown in Figure 1.

At the time of the overhead flights, luminance measures were made on the ground and ground photographs of the targets were taken.

At the suggestion of the sponsor, additional flights were made over Ft. Meade, Maryland, to obtain a larger sample of targets for the study. The ground resolution of the photography obtained was estimated at 1.5" from three-bar targets.

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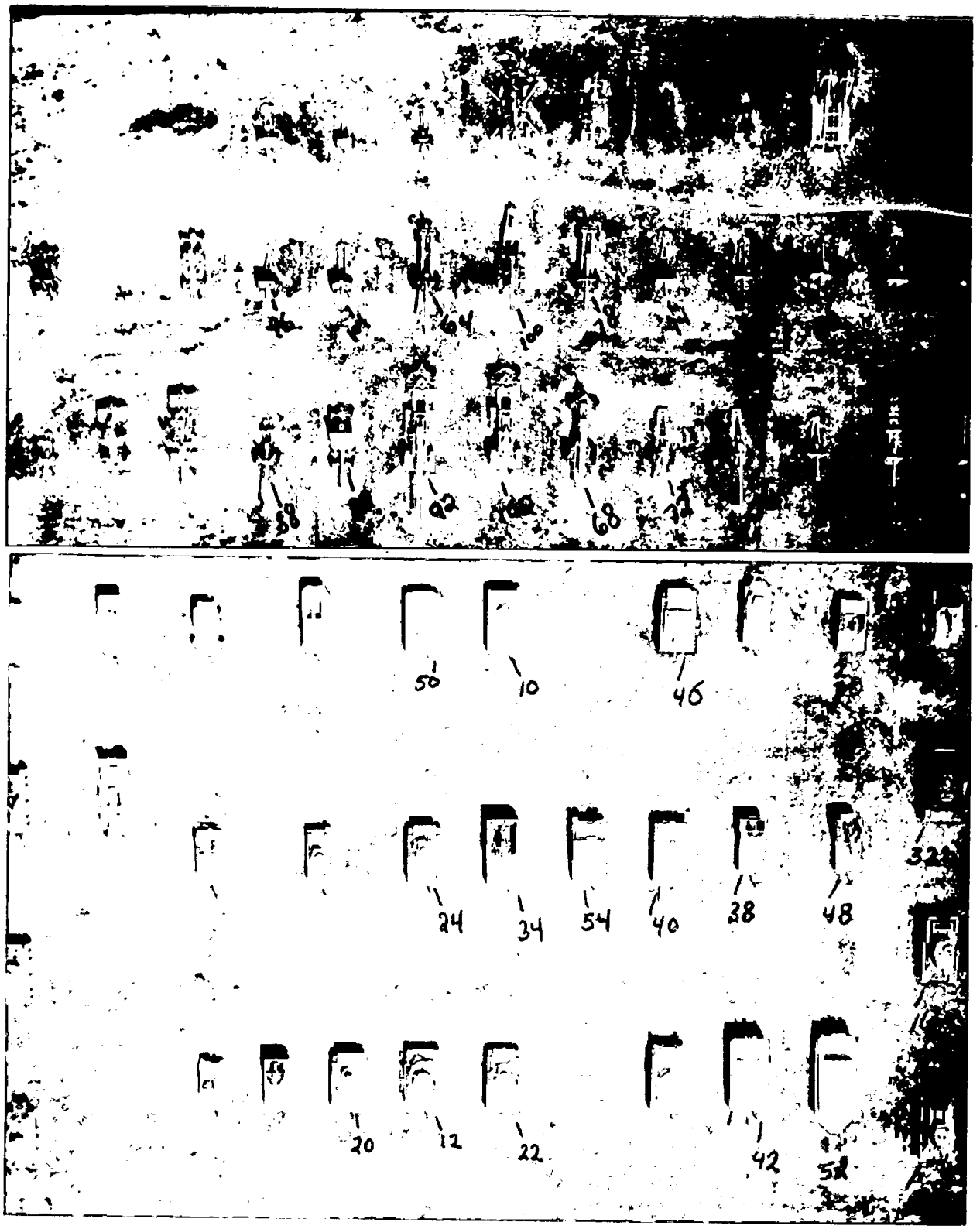

Fig. 1. Second generation paper prints of the Aberdeen Proving Ground tank and artillery museum.

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Second generation paper prints of the Ft. Meade photography are shown in Figure 2. After the photography had been obtained, it was necessary to perform additional tasks in preparation for the experimental study:

1. Obtain photographic images representing five ground resolutions and prepare an MTF and ground resolution estimate for each.

2. Obtain "ground truth" for the additional photographic coverage.

3. Prepare a study plan.

Item 1 above, obtaining photographs representing five ground resolutions, implied obtaining five ground resolutions of one or two scenes. Actually, six ground resolutions of six scenes were prepared by Eastman Kodak from the original negatives. The need for additional "ground truth" information was a result of obtaining the additional targets and scenes at Ft. Meade. That "ground truth" was obtained.

STUDY PLAN

A study plan was prepared but this work was done before the photographs were prepared by Eastman Kodak. Thus, it was not possible to perform a pilot study, and the plan cannot be considered complete. It was not possible, for example, to determine how difficult it is going to be to point at the targets to be identified, how long it is going to take the PIs to "read out" each frame, or the best way to index and present the "ground truth" information.

It is assumed now that the method will be essentially the same as that used in the previous studies. Experienced PIs will view the targets at each ground resolution, starting with the poorest and ending with the best. At each resolution, they will attempt to identify each target by comparing its image in the photographs with the "ground truth" information.

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Fig. 2. Second generation paper prints of targets at Ft. Meade.

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Fig. 2 (Cont.)

The data will be analyzed to determine the mean, standard deviation, and standard error of the mean of percent correct identifications at each ground resolution. Tests of the statistical significance of differences in identification performances between and among ground resolutions will be made. A description of the method and the results and their implications will be presented in a technical report.

Following is a more detailed description of the method.

Experimental Photographs

The ground resolution of the photography is approximately [redacted] The original negatives were processed to obtain . 25X1

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six ground resolutions and scales that are relevant to existing and proposed systems, as shown in the table below.

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Targets

As previously mentioned, representatives of the sponsor and other intelligence organizations suggested that the effects of ground resolution on the identification of ground order-of-battle targets should be investigated. Consequently, a study was done first of the effects of ground resolution on the accuracy of identification of scale models of military vehicles--tanks and other types of vehicles.

The sponsor requested that an additional study with real ground order-of-battle targets be conducted. So photographs of the World War II tank/artillery museum at Aberdeen and more modern targets at Ft. Meade were obtained.

There may be a question concerning whether or not the targets are representative of the ground order-of-battle targets that PIs seek to identify today. They appear to be. First, some of the World War II tanks and artillery pieces at Aberdeen and the vehicles photographed at Ft. Meade are in use today; second, the external configurations of the tanks and artillery pieces developed since World War II, and being used today, are not signifcantly different from those used in

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World War II; and, third, the visual discriminations required to identify World War II ground order-of-battle targets are not different from the visual discriminations required to identify modern ground order-of-battle targets.

Experimental Design

The major question in designing a study of the effects of ground resolution on PI performance is whether to use a *within-* or *between-subjects* design. In the within-subjects design, all subjects view the imagery at all ground resolutions and thus serve as their own controls. The advantage of such a design is that because the subjects serve as their own controls, some experimental control is maintained over relevant variables such as knowledge, experience, and aptitude. There are disadvantages to the within-subjects design. The number of hours required per subject is much larger, and subject motivation and performance can deteriorate over time. There may be uncontrolled "order effects," and the order effect of greatest concern is the learning that takes place during the course of the experiment.

In the between-subjects design, a different group of subjects views the imagery at each ground resolution. Thus, when a comparison is made among the performances at the various ground resolutions, not only are the effects of ground resolution being compared, individual differences in knowledge, experience, and aptitude are also being compared.

In the previous experiments, within-subjects designs have been used. If the task is not too time consuming, the same type of design will be used again. A pilot study will be done to determine how long it takes a subject to complete the entire target identification task working from the poorest imagery to the best. If the time taken is considered reasonable, a within-subjects design will be used. If the time required is considered too long, a combination within- and

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between-subjects design will be used, as illustrated below.

GROUND RESOLUTION

[redacted]					
Group I	Group II	Group I	Group II	Group I	Group II

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Comparisons betwee[redacted] 25X1

[redacted] will be within subjects. Other comparisons will be between subjects. Obviously, a pilot study must be done before final design decisions can be made. 25X1

Subjects

Professional PIs with a minimum of one year of recent operational experience will serve as subjects and an effort will be made to use only ground order-of-battle specialists. From 20 to 30 subjects should be enough to achieve adequate reliability, yet not seriously interfere with operations.

Data Collection

The data collection will be conducted at NPIC. A room with three viewing stations comparable to operational stations will be set up and an effort will be made to have three subjects perform at a time. Each station will include a light table, a B and L microscope, and a tube magnifier.

Data Analysis

Means, standard deviations, and standard errors of the mean of percent correct target identifications at each ground resolution will be computed. Different classes of targets will be treated separately. Analyses of variance will be performed to determine the overall significance level of ground resolution as a function of target type. Statistical tests of the differences between pairs of means will be made

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as required. Other analyses will be performed if they appear possibly to reveal relevant information.

The data analysis will be done on the [redacted] IBM 1130 computer, using programs especially designed for the study. 25X1

Technical Report

The technical report will contain a summary, an introduction, a detailed description of the method and results, conclusions, and discussion. Briefings will be given at the request of the sponsor.

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