**Technical Research Note 205**



# CHANGE DETECTION IN AERIAL PHOTO COVERAGE AS INFLUENCED BY METHODS OF COMPARISON

C. L. Klingberg and C. L. Elworth,
The Boeing Company

and

S. Epstein
System Development Corporation



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U. S. Army
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C. L. Klingberg and C. L. Elworth,
The Boeing Company

and

S. Epstein
System Development Corporation

Abraham H. Birnbaum, Task Leader

SUPPORT SYSTEMS RESEARCH DIVISION
Joseph Zeidner, Chief

U. S. ARMY BEHAVIORAL SCIENCE RESEARCH LABORATORY

Office, Chief of Research and Development
Department of the Army

Room 239, The Commonwealth Building
1320 Wilson Boulevard, Arlington, Virginia 22209

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## FOREWORD

The Surveillance Systems research program of the U. S. Army Behavioral Science Research Laboratory has as its objective the production of scientific data bearing on the extraction of information from surveillance displays and the efficient storage, retrieval, and transmission of this information within an advanced computerized image interpretation facility. Research results are used in future systems design and in the development of enhanced techniques for all phases of the interpretation process. Research is conducted under Army RDT&E Project 2Q662704A721, "Surveillance Systems: Ground Surveillance and Target Acquisition Interpreter Techniques," FY 1969 Work Program.

BESRL research in this area is conducted as an in-house research effort augmented by research contracts with organizations selected as having unique capabilities and facilities for research in aerial surveillance. The present study was conducted jointly by personnel of the Boeing Company and the System Development Corporation and of the Behavioral Science Research Laboratory under program direction of A. H. Birnbaum.

The INTERPRETER TECHNIQUES Work Unit seeks to develop methods and procedures which maximize the accuracy, completeness, and speed with which intelligence information is derived from imagery, both conventional aerial photographs and the products of advanced sensor techniques. The present publication reports on a study of methods of comparing current with prior imagery cover of a given area as means of detecting change in the status of targets in the area.

J. E. UHLANER, Director
U. S. Army Behavioral Science
Research Laboratory

# CHANGE DETECTION IN AERIAL PHOTO COVERAGE AS INFLUENCED BY METHODS OF COMPARISON

## BRIEF

Requirement:

To investigate the effects of selected variations in procedure--methods of comparing current with prior imagery cover, familiarity of the interpreter with the area, and time allowed for interpretation--on the completeness and accuracy with which change in the status of targets is detected.

Procedure:

Sixty-four student interpreters performed a target (military vehicles) change detection task. Comparison materials provided were either pairs of unannotated photos, pairs of photos o .e of which was annotated, or schematic photo overlays plus written reports of earlier coverage, paired with a more recent photo. In a fourth procedure, separate analyses of the comparative photos were made and the data subjected to a simulated computer comparison procedure. Each comparative scene was viewed for either 5 or 15 minutes. Half the subjects had gained familiarity with the target areas through a prior interpretation and half had not. Change detection performance was evaluated in terms of completeness and accuracy.

Findings:

Under the 5-minute time limit, the computer comparison of independent interpretations of current and prior photo coverage resulted in more complete change detection than did the other methods employed and about the same degree of accuracy. The advantage of computer comparison was less marked under the 15-minute time limit.

Providing the interpreter with overlay plus a written report on the prior imagery was the least effective of the comparison methods investigated. Without the actual imagery from the earlier mission, the interpreter has no way of correcting errors in the earlier interpretation. The method also was time-consuming.

Interpreter familiarity with the terrain through preparation of reports on the prior imagery resulted in more complete and more accurate change detection under the 5-minute time limit. Under the 15-minute time lim :, the advantage was negligible.

Utilization of Findings

When fast change detection is necessary and work time allotted is short, more complete change detection can be attained by use of a computerized system of comparing data extracted separately from current and prior photographic imagery. Consideration of such a procedure has been recommended for advanced surveillance systems.

When the comparison for change detection is to be made by an interpreter, there is an advantage, under extreme time pressure, in having the interpreter of the prior imagery make the comparison.

Inspection of current imagery and use of overlays and reports based on prior imagery should be used to obtain information on target change status only if none of the alternative methods described is feasible.

CHANGE DETECTION IN AERIAL PHOTO COVERAGE AS INFLUENCED BY METHODS OF COMPARISON

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# CHANGE DETECTION IN AERIAL PHOTO COVERAGE AS INFLUENCED BY METHODS OF COMPARISON

## THE PROBLEM

### Need for Multiple Cover Imagery

The increased mobility of military personnel, weapons, systems, and support equipment, and the greater firepower capability of small operational units have placed new emphasis on need for comprehensive and timely military intelligence information. Crucial to maintaining full cognizance of enemy activity is the detection of changes in the status and deployment of military forces through acquisition and interpretation of comparative-cover aerial photography. Detailed inspection of aerial photographs taken of the same terrain at different times can provide critical intelligence information regarding the enemy's strength, deployment, activity, and battle plan not readily available from other sources.

Comparative-cover change detection performance is affected by many situational factors. The training and experience of the interpreter (both general and specific to the task and terrain), the interpretation procedures followed, the amount and nature of the comparative materials the interpreter has available, the amount and characteristics of the display and support equipment he uses, and the stated or inferred requirements of the intelligence task, all contribute to the accuracy, completeness, relevance, and timeliness of the interpreter's report.

Among the numerous factors influencing change detection performance, of immediate significance are 1) type and amount of information on the earlier coverage and how the earlier coverage is used, 2) the interpreter's familiarity with the target area, 3) time allocated for the change-detection task, 4) similarity of photo scale and directional orientation of the early and late coverage, and 5) compatibility of photo dissimilarities with display device requirements. The present study was concerned primarily with the first three of these procedural variables. The objective was to study the effect of variations in these procedures on the completeness and accuracy of change detection from tactical comparative cover imagery.

### Variations in Methods of Comparison

From among the numerous forms of comparison materials an interpreter might use in detecting changes in a given section of terrain, four were selected as representative of the range of situations encountered under most operational conditions:

Unannotated Photos. Perhaps the most frequent procedure is a straightforward comparison of two unannotated photos (UP) taken of a target area at different times. The interpreter searches each photo, scanning back and forth between the two to find the targets and determine their change status.

Annotated Photos. Often the earlier photo ($P_1$) has to be retrieved from a storage file and combined with a newly acquired photo ($P_2$) to form a comparative-cover photo pair. The earlier photo may have been analyzed when it was first obtained, and annotated in the process to indicate the targets detected. This annotated photograph (AP), may have been annotated by the same interpreter who is making the comparison, or the annotations may have been made by some other interpreter.

Overlay plus Written Report. In addition to annotating photographs in the process of interpreting them, it is almost always a requirement that a written report of the findings also be prepared. Content and format of these reports will vary as dictated by objectives of the mission for which they were prepared. Schematic situation overlays or photo overlays may also have been prepared, and may be found with the written report in the files. The combined situation overlay and written report (OR) prepared from the earlier imagery serves as comparison material for assessment of target changes in the more recent imagery.

Computer Comparison. In the computerized comparison condition (CC), the interpreter analyzes the late cover only. The computer makes the earlier image sample comparison and prepares the change detection report. With the advent of small field model computerized information storage and retrieval systems, it may become possible for previously acquired intelligence data on the location and identification of enemy forces to be encoded and stored in the computer's memory bank for future query and recall. The interpreter would have only to locate and identify targets on the new photographs and then query the computer as to the presence or absence of any previously reported target at a given location (specified by means of a compatible coordinate system). The interpreter could then make statements about targets common to early and later coverage and also identify targets found in the new imagery but not in the earlier imagery. By requesting a complete readout on the location and identification of all targets previously reported, he can determine which targets are gone from the area or are new to the area. The more sophisticated computer may even perform the change detection comparison internally, requiring only the encoded data on target location and identification from the two image samples. The computer then compares, integrates, itemizes, and prints out information on location and identification of targets and change status. The accuracy and completeness of such a computer-generated report is dependent, however, on the accuracy and completeness of the two independent inputs which are to be compared. It is this sophisticated computer system that was simulated for experimentation in the present study.

### Area Specialization of Interpreter

A second variable selected for investigation was whether a given interpreter should be assigned prime responsibility for specific terrain areas and all imagery of those areas routed to him. The hypothesis being tested was that familiarity with a specific locale provides the interpreter with an accumulated background of critical information about the area such that he can more accurately and rapidly perform subsequent comparative-cover analyses of the area. In the present study, an interpreter who, prior to engaging in the change detection task, had interpreted earlier coverage of a given area was considered an "experienced" interpreter, while one who was looking at a given area for the first time was considered to have "no experience". With the unannotated photo experimental condition, the experienced operator had interpreted the earlier imagery at some time prior to the change detection task, whereas the no-experience interpreter had had no previous experience with either of the comparative cover pair. In the case of the annotated photos and the overlay plus written report conditions, the annotations and other reference materials had been prepared by the experienced interpreter, while the no-experience interpreter had to rely on reference materials generated by some other interpreter. For experienced interpreters performing under the simulated computer-comparison condition, the data on the earlier imagery ($P_1$) against which the $P_2$ input was compared were provided by the same subject as the $P_2$ data; $P_2$ information provided by no-experience interpreters was compared with $P_1$ information supplied by some other interpreter.

### Time Requirements

With the increased perishability of reconnaissance information in today's highly mobile warfare tactics, the rate at which intelligence data can be extracted from imagery becomes of paramount importance. Two work periods, one judged to be sufficiently short (5 minutes) to permit assessment of information loss through the effects of time pressure, and the other (15 minutes) long enough to permit most subjects to complete the task easily, were established and imposed on the subjects.

## METHOD

### Experimental Design

The four methods of comparing early and late imagery, the two levels of interpreter specialization (experience with the target area vs no experience), and two time limits (5 minutes and 15 minutes) were combined into the 16 experimental conditions shown schematically in Figure 1. Each of 16 matched groups of four subjects each performed the target search, target identification, and change detection task under one experimental condition (Table 1). Measures of completeness and accuracy of change detection without requirement of target identification and like measures with requirement of target identification by category were obtained. Analysis of variance was conducted separately for each of the two levels of identification.

### Subjects

Subjects were 64 student interpreters (enlisted men) nearing completion (12th week of the 15-week course) of the image interpreter course at the U. S. Army Intelligence School, Fort Holabird, Maryland. Participants were drawn from several classes. Sixteen groups of four each were formed, groups being matched on scores on the General Technical Aptitude Area (GT), a composite of the Verbal and Arithmetic Reasoning tests of the Army Classification Battery (See Table A-1 of Appendix A).

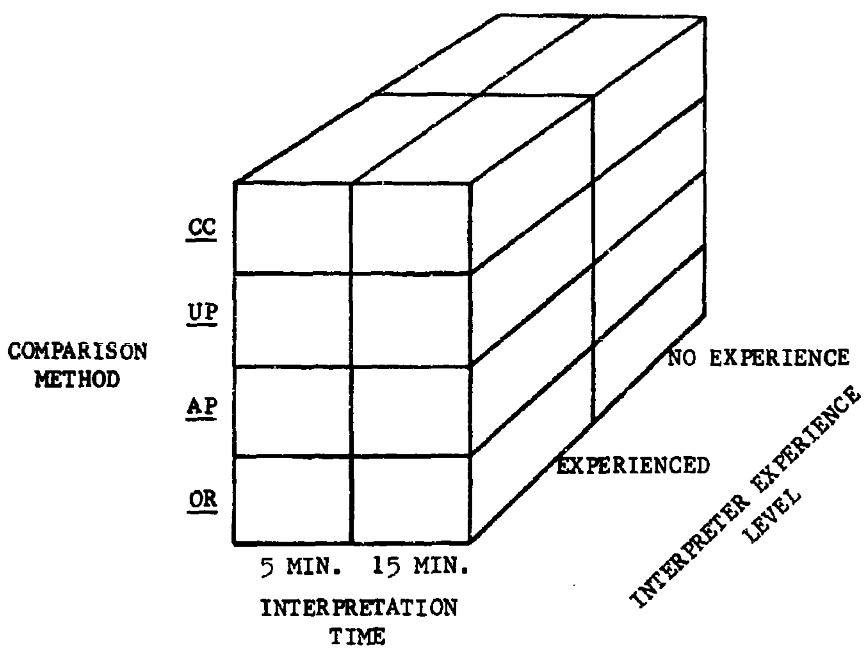


Figure 1. Schematic representation of experimental conditions

**Table 1**

SUMMARY OF EXPERIMENTAL CONDITIONS

| Group No. | Comparison Materials[a] | Method of Comparison | Experience with Area | Time Limit |
|---|---|---|---|---|
| 1 | $P_2$ only | CC | No Experience | 5 Min. |
| 2 | $P_2$ only | CC | No Experience | 15 Min. |
| 3 | $P_2$ and $P_1$ unannotated | UP | No Experience | 5 Min. |
| 4 | $P_2$ and $P_1$ unannotated | UP | No Experience | 15 Min. |
| 5 | $P_2$ and $P_1$ annotated | AP | No Experience | 5 Min. |
| 6 | $P_2$ and $P_1$ annotated | AP | No Experience | 15 Min. |
| 7 | $P_2$ and overlay and Report Form of $P_1$ | OR | No Experience | 5 Min. |
| 8 | $P_2$ and overlay and Report Form of $P_1$ | OR | No Experience | 15 Min. |
| 9 | $P_2$ only | CC | Experienced | 5 Min. |
| 10 | $P_2$ only | CC | Experienced | 15 Min. |
| 11 | $P_2$ and $P_1$ unannotated | UP | Experienced | 5 Min. |
| 12 | $P_2$ and $P_1$ unannotated | UP | Experienced | 15 Min. |
| 13 | $P_2$ and $P_1$ annotated | AP | Experienced | 5 Min. |
| 14 | $P_2$ and $P_1$ annotated | AP | Experienced | 15 Min. |
| 15 | $P_2$ and overlay and Report Form of $P_1$ | OR | Experienced | 5 Min. |
| 16 | $P_2$ and overlay and Report Form of $P_1$ | OR | Experienced | 15 Min. |

[a] $P_1$ = earlier photo; $P_2$ = later photo

### The Experimental Task

The task to be performed was the preparation of updated annotated photographs and written reports for ten different scenes in which tactical military targets appeared. The process of updating included the following activities: target detection and localization, target identification, change detection, photo annotation, and preparation of report.

Change Detection without Target Identification. This level of identification required only that the interpreter state whether an object was a target or a non-target. Having determined a detected object to be a target, the interpreter then checked the comparative photo to determine whether the target was present or absent at the same location. If he found the target present only on the earlier imagery, he labeled it "Gone" on the second photo; if he found the reverse, he labeled the target "New" on the second photo. If the object was seen as present in the same location on both photos, the interpreter was required to make a same-different judgment prior to assigning a change status of "Unchanged" or "Replaced". Erroneous change status assignments could thus result from one or more of several errors: failure to detect the presence of a target or targets, failure to distinguish between target and non-target objects, detecting an object where there was none (inventive errors), failure to translate accurately target locations in comparing photos, and failure to make the correct same-different discrimination.

Change Detection with Target Identification. At this level, the interpreter was required to identify the target as belonging to one of nine target categories listed on the Response Code Sheet (Figure 2). Having detected and identified a target, he proceeded to assign the change status designation as at the detection level. In addition, where a target was uniquely identifiable, the change status "Moved" was applicable if the target had been repositioned within the same general area. All sources of erroneous change status assignment cited above were applicable to the identification level of response, plus misidentification of detected targets.

The method of evaluating interpreter performance placed maximum emphasis on the change detection aspect of the task. In scoring, a change status assignment was counted as correct only when the total present-absent and same-different comparison had been accurately performed.

| RESPONSE CATEGORIES | CONFIDENCE LEVELS | CHANGE STATUS |
|---|---|---|
| 1. Tanks (includes M41, M48, M60) | C -- Certain | U -- Unchanged |
| 2. SP Howitzers & Guns (includes M42, M44, M53, M55, M56, M108, M109) | FS -- Fairly Sure | M -- Moved (within area) |
| 3. Armored Personnel Carriers (includes M59, M113, M114) | D -- Somewhat Doubtful | N -- New |
| 4. Trucks - 3/4 Tons & Less (includes M37, M38, M151) | G -- Best Guess | G -- Gone |
| 5. Trucks - 2-1/2 Tons & Greater (includes M34, M35, M36, M41, M54, M55, M49) | ? -- Something | R -- Replaced |
| 6. Trailers & Semi-Trailers (includes Cargo, Water, Gas, Tank Transport) | | |
| 7. Engineering Equipment (includes Cranes, Graders, Scoops, Tractors, etc.) | | |
| 8. Aircraft (includes fixed & rotating wing) | | |
| 9. Others (includes Wrecker, M543 & M62; Truck Tractors, M52 & M123; Recovery Vehicle, M88; does not include Tents, buildings, stock piles, roads, railroads, rivers) | | |

Figure 2. Reproduction of Response Code Sheet used in the experiment

## Test Materials and Equipment

Photography. From photography available in BESRL's Technical Support Branch Film Library, negatives for ten sets of comparative-cover aerial photographs of Camp Drum, New York were selected. Selection was based primarily on number of targets and target types within each pair and the resultant total representation in the final test sample. Number and distribution of targets and types of change contained in each photo pair are shown in Table A-2 of the Appendix. Scale, image quality, dominant terrain characteristics, and amount of overlap were not systematically controlled (see Table A-3). Positive black-and-white transparencies in a 9" by 9" format were prepared in sufficient quantity to provide each of the 64 subjects with the required ten sets of imagery for analysis under their assigned conditions.

Materials. A Response Code Sheet (Figure 2) was prepared to enumerate and describe the nine target response categories to be used in reporting the identification of targets detected, confidence levels to be used in association with each identification, and the five types of change status. The confidence rating was included in order to simulate more closely operational procedures where it is common practice of interpreters to rate their confidence on the information they report. An Immediate Report Form (Figure 3) was provided with each photo pair to standardize target reporting and identify subject, experimental condition, and stimulus material.

Each subject was issued a 9" by 9" transparent celluloid target localization grid, ruled off into 144 consecutively numbered cells 3/4-inch square. When overlaid on the most recent coverage of each comparative photo pair, the grid provided a numerical reference system for reporting the location of the detected targets. Interpreter keys for the identification of U. S. military vehicles were made available to all subjects for study prior to the test session and for reference as needed during the test. All additional supplies--grease pencils for annotating photos, tracing paper for preparing overlays, etc.--were provided by the experimenters.

Display and Viewing Equipment. Regulation government-issue variable-illumination swivel-top light tables were provided for viewing the positive transparencies. Each subject had his own photo-interpretation kit from which he was free to use whatever aids he desired--magnifiers, for example--in performing the assigned task.

U. S. ARMY BEHAVIORAL SCIENCE RESEARCH LABORATORY
WASHINGTON, D. C. 20315

IMMEDIATE REPORT FORM

Name____________________ Man No. ____________________

Date____________________ Perf. Meas. No. ________________

| Item No. | Object Name | Change Status | Confidence | Target Location | Time |
|---|---|---|---|---|---|
| | | | | | |

Figure 3. Reproduction of Immediate Report Form used in the experiment

### Experimental Procedure

As each experimental group arrived at the test site for the first time, subjects were given a short briefing on the objectives and procedures of the experimentation in which they were about to participate. They were given a sufficient amount of information concerning the variables under investigation to make the task meaningful to them, and the implications and applications of their efforts were emphasized to instill a positive motivational set (see Instructions to Subjects in Appendix B). A test packet containing materials for the test (photos and/or reference materials, ten Immediate Report Forms, a Response Code Sheet, a transparent reference grid, a copy of the PI Key to U. S. Military Vehicles, tracing paper, and grease pencils) was then distributed to each subject.

Subjects were instructed on 1) use of the Immediate Report Form to record their responses (sequential numbering of detected targets, coding of target identification by target class, reporting of target location by grid cell designation, code designation of each test photo, basis for establishing and recording change status judgments, and indication of lapsed interpretation time); 2) meaning and application of each of the items on the Response Code Sheet; and 3) procedure to follow in preparing the annotated photos (e.g., circle with grease pencil and number consecutively all targets detected on, and missing from, the later imagery) and in producing the situational overlays (e.g., include all detected targets and enough surrounding detail to permit subsequent matching with other imagery).

The 32 subjects serving as experienced interpreters participated in two test sessions, whereas the no-experience groups participated in only one. In the first session, the experienced subjects produced annotated photographs, situational overlays, and written reports (exclusive of change status determination) for the earlier cover ($P_1$). No time limit was imposed. In the second session for those designated experienced subjects, which took place 24 hours after the first, subjects were responsible only for annotating the later imagery ($P_2$) and preparing an Immediate Report Form for each photo. No overlay was required. Inspection time was limited to either 5 or 15 minutes per picture. Subjects were also required to make change status statements for each target by making reference to the $P_1$ information provided (or remembered). The no-experience interpreters, having only one session, were required to produce annotated $P_2$ photos and Immediate Report Forms similar to those being prepared by the experienced subjects in their second test session.

The $P_1$ material supplied to the subjects for comparison with the $P_2$ imagery varied with experimental condition. The experienced subjects who were designated to work with annotated photo imagery received the annotated $P_1$ photos which they themselves had prepared in the previous test session. The experienced subjects working under the overlay-and-report condition received, along with the $P_2$ imagery, the 10 overlays and Immediate Report Forms they had themselves prepared the day before. From materials prepared by the remaining 24 experienced subjects in their first session, the annotated imagery and overlay-report reference material were selected for the no-experience subjects. Annotated photos and overlays plus report were randomly selected and paired with the appropriate $P_2$ image. Except for the computer-comparison groups, each no-experience subject received comparative $P_2$ materials prepared by a randomly selected 10 out of the 24 experienced subjects. Input for each of the 10 $P_2$ scenes an individual was to analyze had been prepared by a different experienced subject.

Questions relating to the procedures were answered and the testing was conducted with three experimenters continuously monitoring the subjects to assure adherence to the time limit imposed. Subjects were given the tests in their normal classrooms during regular duty hours. Four group sessions were held with up to 20 subjects participating in each session.

## Scoring

Data Obtained. The units of information obtained by the reporting procedure described included:

1. A target position report localizing each of the detected targets within one of the 144 cells dividing the photograph.

2. A coded identification of the target class (one of nine categories) to which each detected target was judged to belong.

3. A coded statement--Unchanged (U), Moved (M), Gone (G), New (N), or Replaced (R)--of the judged status of each reported target as determined from comparison of the two image samples or image sample and reference data.

Individual responses were scored by comparing each report of a target location, identification, and change status with "interpreter truth" data provided by a team of experts in the U. S. Army Behavioral Science Research Laboratory. The interpreter truth for each target on a photo pair--target, location, and change status--was encoded and transcribed on punched cards. The responses to these targets as reported by each subject were similarly encoded and transcribed from the Immediate Report Forms to the same cards. Inventive errors were identified and entered separately. Comparison of the transcribed responses with interpreter truth yielded quantitative data on 1) number of targets correctly detected ( and by subtraction, number omitted); 2) number of correctly detected targets which were correctly identified and the number incorrectly identified; 3) number of correct and incorrect change status assignments; and 4) number of inventive errors committed along with number of erroneous identifications and change status designations associated with the inventive error.

## Evaluative Measures

From the response data available, evaluations of interpreter performance were derived for application in assessing the effects of the independent variables. Separate measures of interpreter performance were computed for change status detection without identification of target and for change status detection requiring target identification.

Change Status Completeness. The completeness of interpretation is the ratio of the number of correct change status responses to the total number of correct change status responses possible. In equation form:

$$\text{COMPLETENESS} = \frac{\text{Number of Correct Change Status Responses}}{\text{Total Possible Correct Change Status Responses}} \text{ .}$$

Change Status Accuracy. The accuracy of interpretation is the ratio of the number of correct change status responses to the total number of change status responses (both correct and incorrect) reported by the interpreter subject. In equation form:

$$\text{ACCURACY} = \frac{\text{Number of Correct Change Status Responses}}{\text{Total Number of Change Status Responses Reported}} .$$

To provide comparable performance measurement units from photo pairs containing different numbers of targets, the completeness and accuracy scores of each subject were averaged over all photo pairs viewed under each experimental condition to yield mean performance figures for each treatment condition.

## RESULTS

### Completeness of Change Detection

Change Detection without Target Identification. Table 2 presents the mean completeness scores for the change status responses when target identification was not required. Significant main effect differences were found for all independent variables (see analysis of variance summary table 4 in Appendix A).

The experienced groups generally performed considerably better than did the no-experience groups (56% and 48%, respectively). The simulated computer comparison condition, relying on separate interpretations of the two comparative cover photos and determination of change status by a computer method, was best (67% completeness), followed by comparative cover interpretation of later cover with an annotated photograph and with an unannotated photograph (51% and 50%, respectively) of earlier cover. The poorest performance was with the procedure relying on written reports and photo overlays for comparison with the photo representing the later coverage (38% completeness).

As anticipated, additional interpretation time resulted in more complete change detection reports. Of the possible change status assignments, 61% were provided after 15 minutes as compared with only 43% after 5 minutes.

Two significant interactions were indicated: 1) Experience with the area by Method of Comparison, and 2) Experience by Method of Comparison by Time. The Experience by Comparison Method interaction suggests that, whereas both the experienced and the no-experience interpreters performed about equally well under the computer comparison where the task was essentially one of normal single frame interpretation not involving direct change detection (mean completeness scores were 67% and 68%), for the other comparison methods the experienced group did consistently better than the no-experience group. This result was not unexpected, since the experienced group had the advantage of working with reference materials they themselves had generated whereas the no-experience group worked with unfamiliar early coverage materials generated by others. The Interpreter Experience by Comparison Method by Time interaction may result from the fact that the experienced interpreters performed substantially better with short inspection time using their own overlay plus written report materials than did the no-experience interpreters using materials prepared by others. This advantage was evident only in the overlay plus written report (OR) method under the 15-minute time limit. The difference in completeness between the two experience groups under the 15-minute work time with the OR method may derive from the fact that the no-experience interpreter cannot correct or supplement the early report since he has not seen the earlier cover, whereas the experienced interpreter, comparing current imagery with a report that he himself prepared, can supplement his OR comparison with his recollections of the earlier imagery.

One additional finding is of interest: Although a significant interaction for Time by Comparison Method was not found, the average completeness for the computer comparison method increased only very slightly with an increase in time (from 66% to 68%) relative to those for the other conditions. It would appear that the computer comparison method is generally superior to the others, with very little gain to be derived from adding more inspection time.

Table 2

MEAN COMPLETENESS SCORES FOR CORRECT TARGET CHANGE WHEN TARGET IDENTIFICATION WAS NOT REQUIRED

| | Groups | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | No-Experience | | | Experienced | | | Combined | | |
| | Time Limits | | | Time Limits | | | Time Limits | | |
| Reference Materials | 5 Min | 15 Min | Means | 5 Min | 15 Min | Means | 5 Min | 15 Min | Means |
| CC | .663 | .686 | .675 | .653 | .683 | .668 | .658 | .684 | .671 |
| UP | .223 | .660 | .441 | .512 | .610 | .561 | .368 | .635 | .501 |
| AP | .318 | .619 | .468 | .489 | .621 | .555 | .404 | .620 | .512 |
| OR | .244 | .383 | .314 | .322 | .590 | .456 | .283 | .486 | .385 |
| Means | .362 | .587 | .475 | .494 | .626 | .560 | .428 | .606 | .517 |

__Change Detection with Target Identification__. The results for this analysis were essentially similar to those for performance at detection level, except that completeness was generally lower--a not surprising finding, since the added requirement for target identification was contingent upon target detection. In addition to each main effect, all interactions were significant (see Appendix Table A-5). Table 3 presents the mean performance values for this response level.

The experienced group performed generally better than the no-experience group (40% vs 35%). The computer comparison condition resulted in better performance than the two photo-comparison conditions, which in turn were better than the overlay plus report condition (completeness scores were 48%, 38%, 37%, and 28%, respectively). The 15-minute time allowance resulted in more complete performance than the 5-minute allowance (44% vs 32%).

The Experience by Comparison Method interaction again indicated that experienced interpreters performed significantly better than no-experience interpreters when they use comparison materials which they have themselves generated. The Experience by Time interaction was also found to be significant. Experienced interpreters performed better in the 5-minute time period than did the no-experience interpreters, but there was no such difference with the 15-minute period. Mean completeness scores for experienced and no-experience interpreters were 37% and 27%, respectively, for 5-minutes of interpretation and 44% and 44% for the 15-minute time period.

The Time by Comparison Method interaction indicated that additional time is helpful under all conditions other than the computer comparison, under which performance was slightly degraded with the longer inspection time. Completeness under this condition was 52% with the 5-minute period and declined to 46% with the 15-minute period.

The Experience by Comparison Method by Time interaction again indicated that experienced interpreters performed better working with materials they had generated than did the no-experience interpreters working with reference materials generated by others under the 5-minute time allowance. Under the 15-minute time period, the experienced interpreter reached a much higher level of completeness than his no-experience counterpart for the OR comparison method since he could supplement the overlay locations and written report descriptions with his personal recollections. This possible memory advantage was not evident with the Computer Comparison Method where the experienced interpreter was much less complete after 15 minutes than is his no-experience peer.

To summarize the completeness performance results in the study, a computer comparison procedure similar to the one simulated here in which an objective and automated comparison of two independent inputs is performed, can effectively lead to the production of more timely and complete change status reports. It is equally clear that previously established familiarity with the target area and reports from an earlier coverage is particularly advantageous when reporting time is a critical factor.

Table 3

MEAN COMPLETENESS SCORES FOR TARGETS DETECTED, CORRECTLY IDENTIFIED, AND ASSIGNED CORRECT CHANGE STATUS

| Reference Materials | Groups | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | No-Experience | | | Experienced | | | Combined | | |
| | Time Limits | | | Time Limits | | | Time Limits | | |
| | 5 Min | 15 Min | Means | 5 Min | 15 Min | Means | 5 Min | 15 Min | Means |
| CC | .505 | .524 | .515 | .524 | .385 | .455 | .515 | .455 | .485 |
| UP | .193 | .471 | .332 | .372 | .467 | .420 | .282 | .469 | .376 |
| AP | .198 | .492 | .345 | .362 | .421 | .392 | .280 | .457 | .368 |
| OR | .177 | .251 | .214 | .228 | .483 | .356 | .203 | .367 | .285 |
| Means | .268 | .435 | .351 | .372 | .439 | .405 | .320 | .437 | .378 |

### Accuracy of Change Detection

Change Detection without Target Identification. Directional trends for accuracy of change detection were in fair accord with those for completeness although only two main effects--Experience and Method of Comparison--were found to be significant at the .05 level (Appendix Table A-6). As in the case of completeness scores, the experienced interpreters tended to perform better than the no-experience interpreters when all viewing conditions were considered. Mean accuracy score of experienced interpreters was 79% as opposed to only 72% for no-experience interpreters (Table 4). In regard to Comparison Method, the computer-comparison condition provided 80% accuracy, roughly equivalent to that attained with either the annotated photos (80%) and the unannotated photos (75%). The overlay and report comparison resulted in performance accuracy considerably less than any of the other three (66%).

Only with the accuracy index was there some indication (for no-experience interpreters at least) that when time pressure exists there is an advantage to working with annotated as opposed to unannotated imagery (74% vs 55% accuracy).

Table 4

MEAN ACCURACY SCORES FOR CORRECT TARGET CHANGE STATUS RESPONSES

| Reference Materials | Groups | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | No-Experience | | | Experienced | | | Combined | | |
| | Time Limits | | | Time Limits | | | Time Limits | | |
| | 5 Min | 15 Min | Means | 5 Min | 15 Min | Means | 5 Min | 15 Min | Means |
| CC | .846 | .799 | .822 | .818 | .746 | .782 | .832 | .772 | .802 |
| UP | .549 | .830 | .690 | .792 | .834 | .813 | .671 | .832 | .751 |
| AP | .739 | .824 | .781 | .824 | .804 | .814 | .781 | .814 | .798 |
| OR | .589 | .565 | .577 | .654 | .839 | .746 | .621 | .702 | .661 |
| Means | .680 | .755 | .717 | .772 | .806 | .789 | .726 | .780 | .753 |

Change Detection with Target Identification. As expected, the results of this analysis were essentially the same as those obtained for responses without target identification, although performance was somewhat lower (Table 5). The analysis of variance (Appendix Table A-7) indicated that none of the main effect differences were sufficiently reliable to be of statistical significance. The triple interaction did reach significance at the .05 level. Time and Experience produced different results with the comparison methods employed. Under the 5-minute time limit the experienced interpreters were more accurate than the no-experience interpreters. Under the 15-minute time limit, this greater accuracy differed with experience level and comparison method. The more extreme differences were with the computer comparison and the overlay plus report methods. The experienced men improved in accuracy with the OR method whereas the no-experience men were less accurate under the 15-minute time limit. However, with the computer comparison method, the accuracy of the experienced men deteriorated markedly under the 15-minute time limit whereas the accuracy of the no-experience men declined only a small amount. As stated before, the experienced interpreter appears to have some residual recollection of the imagery he interpreted previously that he can use to supplement the overlay plus written report method. With the computer comparison method, these recollections appear to have worked against him, since he had no documents which showed his interpretations of the earlier imagery.

Table 5

MEAN ACCURACY SCORES FOR TARGETS DETECTED, CORRECTLY IDENTIFIED, AND ASSIGNED CORRECT CHANGE STATUS

| | Groups | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | No-Experience | | | Experienced | | | Combined | | |
| | Time Limits | | | Time Limits | | | Time Limits | | |
| Reference Materials | 5 Min | 15 Min | Means | 5 Min | 15 Min | Means | 5 Min | 15 Min | Means |
| CC | .620 | .588 | .604 | .650 | .421 | .536 | .635 | .505 | .570 |
| UP | .433 | .579 | .506 | .575 | .621 | .598 | .504 | .600 | .552 |
| AP | .470 | .633 | .551 | .581 | .540 | .560 | .525 | .586 | .556 |
| OR | .403 | .366 | .385 | .417 | .668 | .543 | .410 | .517 | .464 |
| Means | .481 | .541 | .511 | .556 | .563 | .559 | .519 | .552 | .535 |

### Analysis of Responses in Terms of Change Status

For readers who are interested in investigating interpreter response tendencies in greater depth, change detection data in relation to type of change is presented in more detail in Appendix C. Included are summary data showing the distribution of correct and incorrect responses for each type of change and the frequency with which inventive errors were made in each type (Table C-1). A second table (Table C-2) shows the distribution of erroneous change status assignments across the incorrect change categories. To facilitate comparison between change categories having different numerical bases, the frequency data have been converted to percentages. A third table gives the raw score distributions. Some cursory conclusions and speculative hypothesizing about causal factors are offered.

## CONCLUSIONS

In general, the method of deriving target change status reports by having interpreters analyze the earlier and later frames separately and submit these inputs to a computer for comparison and change status determination appears promising. This procedure seems to provide change status reports which are both complete and accurate, particularly when interpretation time is limited. This is not to say that conventional comparative cover interpretation involving the comparison of an early and a late photo should be discontinued, since this procedure is still advantageous for certain types of comparison such as target verification and evaluation of construction progress. The range of interpreter activities for which a computerized procedure would be profitable remains to be established, as does also the optimal encoding format for input of the required information.

In the absence of computer comparison capability, conventional comparative cover interpretation involving the simultaneous use of both early and late cover remains the most useful procedure. There does not appear to be any consistent and demonstrable advantage to be derived from providing interpreters with photo pairs which include annotations resulting from an earlier analysis.

Change detection appears to be somewhat superior when the interpreter is already familiar with the target area being viewed. The interpreter familiar with the area is at particular advantage when time is extremely critical. However, lack of familiarity can be compensated for by increasing the time allotted to interpretation. For maximum efficiency of operation, interpreters familiar with a particular area should be assigned to perform subsequent comparative cover analyses of that area.

In the event ample interpretation time is available, it makes little difference whether interpreters are familiar with the area, nor does the type of reference material provided greatly affect the completeness or accuracy of the change status report generated. Non-pictorial (schematic and/or verbal) reference material appears to be a poor basis on which to make change status determinations. If such material must be used, it is desirable that the interpreter use material he has himself prepared.

## APPENDIXES

Table A-1

MATCHING OF TEST GROUPS OF 4 EACH ON THE BASIS OF GENERAL TECHNICAL APTITUDE AREA SCORES

| Group No. | Mean General Technical Aptitude Area Score (N = 4) | Standard Deviation |
|---|---|---|
| 1 | 118.7 | 14.2 |
| 2 | 118.0 | 13.7 |
| 3 | 117.2 | 11.6 |
| 4 | 117.5 | 11.4 |
| 5 | 117.0 | 14.9 |
| 6 | 118.2 | 16.9 |
| 7 | 126.2 | 20.6 |
| 8 | 117.5 | 9.0 |
| 9 | 118.0 | 7.0 |
| 10 | 117.5 | 11.8 |
| 11 | 117.7 | 9.6 |
| 12 | 115.0 | 6.0 |
| 13 | 116.0 | 9.7 |
| 14 | 118.7 | 6.8 |
| 15 | 117.2 | 8.6 |
| 16 | 116.7 | 8.3 |

Table A-2

NUMBER AND DISTRIBUTION OF TARGETS AND TARGET TYPES

| Pair No. | Photo Ident. No. | Days Elapsed | No. of Targets | Target Distribution by Target Class | | | | | | | | | Target Distribution by Change Status | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | Unchanged | Moved | New | Gone | Replaced |
| 1 | D-50/30 D-18/27 | 729 | 45 | 25 | | | 4 | 14 | 1 | | | 1 | | | 27 | 18 | |
| 2 | D-20/43 D-19/67 | 1 | 11 | 5 | | | 4 | 2 | | | | | 1 | 1 | 3 | 6 | |
| 3 | D-25/58 D-21/32 | 2 | 1[illegible] | | | | 4 | 10 | 3 | | | 2 | 2 | | 3 | 14 | |
| 4 | D-45/40 S-00/06 | 755 | 1[illegible] | | | 3 | 5 | 2 | | | | | | | 4 | 6 | |
| 5 | D-45/62 S-00/25 | 755 | 10 | | | | 4 | 4 | 2 | | | | | | 4 | 6 | |
| 6 | D-24/26 D-06/15 | 3 | 23 | | | 12 | 3 | 7 | 1 | | | | | | 11 | 12 | |
| 7 | D-41/14 D-18/80 | 731 | 24 | 12 | | | 10 | 2 | | | | | | | 2 | 22 | |
| 8 | D-45/05 D-37/54 | 5 | 26 | 5 | | 6 | 5 | 6 | 1 | | 3 | | | | 15 | 11 | |
| 9 | D-52/26 D-41/82 | 0 | 11 | | 1 | | 7 | 2 | 1 | | | | | | 9 | 2 | |
| 10 | D-37/48 D-54/85 | 5 | 7 | | | 1 | 4 | 1 | 1 | | | | | | 7 | | |
| | | Total | 186 | 47 | 1 | 22 | 50 | 50 | 10 | 0 | 3 | 3 | 3 | 1 | 85 | 97 | 0 |

## Table A-3

### DESCRIPTION OF UNCONTROLLED IMAGE PARAMETERS

| Photo Pair | Photo Identification Number | Date | Quality | Scale | Percent Common Area |
|---|---|---|---|---|---|
| 1 | D-18/27 | 6 Sept 62 | G | 3500 | 95 |
| | D-50/30 | 5 Sept 64 | G | 2450 | |
| 2 | D-19/67 | 6 Sept 62 | G | 5000 | 85 |
| | D-20/43 | 7 Sept 62 | G | 5200 | |
| 3 | D-21/32 | 10 Sept 62 | G | 900 | 100 |
| | D-25/58 | 12 Sept 62 | F | 2100 | |
| 4 | S-00/06 | 25 July 62 | G | 2900 | 85 |
| | D-45/40 | 8 Sept 64 | F | 3100 | |
| 5 | S-00/25 | 25 July 62 | G | 2900 | 75 |
| | D-45/62 | 8 Sept 64 | G | 3300 | |
| 6 | D-06/15 | 9 Sept 62 | G | 6000 | 100 |
| | D-24/26 | 12 Sept 62 | G | 1900 | |
| 7 | D-18/80 | 6 Sept 62 | G | 3800 | 100 |
| | D-41/14 | 7 Sept 64 | F | 2900 | |
| 8 | D-37/54 | 3 Sept 64 | F | 3500 | 85 |
| | D-45/05 | 8 Sept 64 | G | 2900 | |
| 9 | D-41/82 | 7 Sept 64 | G | 3000 | 90 |
| | D-52/26 | 7 Sept 64 | G | 1500 | |
| 10 | D-54/85 | 8 Sept 64 | F | 4600 | 100 |
| | D-37/48 | 3 Sept 64 | G | 3500 | |

Analysis of Variance Summary Tables

Table A-4

COMPLETENESS SCORES FOR CORRECT TARGET CHANGE STATUS RESPONSES WITHOUT TARGET IDENTIFICATION

| Source of Variance | Sum of Squares | Degrees of Freedom | Mean Squares | F-Ratio |
|---|---|---|---|---|
| Experience (A) | .117 | 1 | .117 | 13.34* |
| Time (B) | .508 | 1 | .508 | 57.88* |
| Reference (C) | .665 | 3 | .222 | 25.27* |
| AxB | .035 | 1 | .035 | 3.94 NS |
| BxC | .051 | 3 | .017 | 1.96 NS |
| AxC | .133 | 3 | .044 | 5.05* |
| AxBxC | .125 | 3 | .042 | 4.75* |
| Residual | .421 | 48 | .009 | |
| Total | 2.056 | 63 | | |

*P < .01

Table A-5

COMPLETENESS SCORES FOR CORRECT TARGET CHANGE STATUS RESPONSE WITH TARGET IDENTIFICATIONS

| Source of Variance | Sum of Squares | Degrees of Freedom | Mean Squares | F-Ratio |
|---|---|---|---|---|
| Experience (A) | .047 | 1 | .047 | 5.28* |
| Time (B) | .219 | 1 | .219 | 24.82** |
| Reference (C) | .323 | 3 | .108 | 12.20** |
| AxB | .039 | 1 | .039 | 4.45* |
| BxC | .088 | 3 | .029 | 3.32* |
| AxC | .169 | 3 | .056 | 6.38** |
| AxBxC | .108 | 3 | .036 | 4.07* |
| Residual | .423 | 48 | .009 | |
| Total | 1.415 | 63 | | |

*P < .05
**P < .01

Analysis of Variance Summary Tables

Table A-6

ACCURACY SCORES FOR CORRECT TARGET CHANGE STATUS RESPONSES
WITHOUT TARGET IDENTIFICATION

| Source of Variance | Sum of Squares | Degrees of Freedom | Mean Squares | F-Ratio |
|---|---|---|---|---|
| Experience (A) | .081 | 1 | .081 | 5.37* |
| Time (B) | .047 | 1 | .047 | 3.09 |
| Reference (C) | .204 | 3 | .068 | 4.50** |
| AxB | .006 | 1 | .006 | .42 |
| BxC | .105 | 3 | .035 | 2.32 |
| AxC | .103 | 3 | .034 | 2.25 |
| AxBxC | .106 | 3 | .035 | 2.33 |
| Residual | .728 | 48 | .015 | |
| Total | 1.138 | 63 | | |

*P < .05
**P < .01

Table A-7

ACCURACY SCORES FOR CORRECT CHANGE STATUS RESPONSES
WITH TARGET IDENTIFICATION

| Source of Variance | Sum of Squares | Degrees of Freedom | Mean Squares | F-Ratio |
|---|---|---|---|---|
| Experience (A) | .036 | 1 | .036 | 1.95 |
| Time (B) | .018 | 1 | .018 | .95 |
| Reference (C) | .113 | 3 | .037 | 2.00 |
| AxB | .011 | 1 | .011 | .60 |
| BxC | .116 | 3 | .039 | 2.07 |
| AxC | .148 | 3 | .049 | 2.63 |
| AxBxC | .162 | 3 | .054 | 2.88* |
| Residual | .900 | 48 | .019 | |
| Total | 1.505 | 63 | | |

*P < .05

APPENDIX B

## CHECKLIST FOR INSTRUCTIONS TO SUBJECTS

I. Orientation Briefing (stressing the need for empirical data which will significantly advance photo-reconnaissance intelligence "state-of-the-art")

II. Introduction of BESRL and Boeing Test Personnel

III. Brief Review of Research Program and Test Plan

A. Three experiments planned for this program

B. Experiment I involves 16 different experimental conditions

1. Primarily to investigate parameters influencing information extraction (accuracy, completeness, and time) from aerial photography.

2. Major current concern is with change detection with comparative cover photography.

3. Performance measures to be obtained during test sessions are not intended to reflect individual aptitudes or skills but serve as representative data base for all PIs. Scores achieved on these tests will not affect class grade at USAINTS.

4. Operational Implications: Variety of field operations conditions represented in test program (i.e., one man vs team approach as reflected in the conditions where S's may or may not have previously interpreted $P_1$, types of reduced or symbolic reference material to be stored and retrieved for subsequent comparisons, delineation of time (or load) requirements to assure maximum efficiency of intelligence systems).

IV. Distribution of Test Materials (Photo packets, grids, etc.) and PI Keys

V. General Test Procedures, Instructions, and Ground Rules

A. Alignment of Imagery and Grid

1. $P_2$ is always to be placed on the light table so that the identification number is located in the lower right corner of the imagery and reads normally. The same is true for "$P_1$ only" when initially interpreted by the "Prior Interpretation" group.

2. The reference grid is to be superimposed over the transparency, so that the lower left corner of each is coincident.

B. Optical Aids

1. Any instruments normally contained in the standard issue PI kit may be used to assist in the inspection.

C. Recording of Responses

1. Immediate Report Form.

a. Col. I. Each item detected must be numbered consecutively in this column and correspond to the numbers which are associated with each of these targets on the annotated photograph and overlay.

b. Col. II. The items detected need not be identified by name but the number corresponding to the appropriate target class (as shown on "Response Categories" sheet) must be placed in third column. If several of the same type targets are located in the same immediate area, a single entry showing quantity and class (i.e., for six tanks, 6 x 1) is permitted.

c. Col. III (To be added by subjects). One of the five change conditions shown on the distributed list must be entered for each target detected. This applies only to targets located within the common ("overlap") areas and where such judgments are appropriate (i.e., where $P_1$ has previously been interpreted and/or reference comparison material is provided along with $P_2$).

d. Col. IV. Indicate the confidence you have that the identification of the detected target is correct by entering one of the letters associated with the five confidence levels for each target.

e. Col. V. Report the location of each target detected (whether new, gone, unchanged, etc.) by recording the cell number (1-144) corresponding to the area in which the target is located. If targets subtend more than one cell or intersect a grid line, report both grid coordinates. Target position should be reported as it appears on the more recent coverage when more than one coverage is provided.

f. Col. VI. Record the time (to the nearest minute) when inspection of each photo or photo-pair was begun and the time when search was terminated (under both self-paced or experimenter paced conditions).

2. Annotated Photographs. With colored grease pencil, numbering each target consecutively; indicate the precise position of each target detected. Annotate only the more recent coverage when more than one photograph is provided. Indicate the location of targets which appear only on the earlier material by drawing a circle around that location on the more recent coverage in which the target would have been found had it not been removed during the intervening time period. Number consecutively all annotations.

3. Situational Overlays (To be prepared during $P_1$ interpretations only). Using the tracing paper provided, prepare an overlay which will include a sufficient amount of detail (terrain features, landmarks, reference points, roads, rivers, etc.) to insure that subsequent users can readily localize the same area on later imagery even if such imagery is of different scale and contains only partial overlap. Include all targets which have been detected, also the identification number of the photograph from which overlay was prepared and the name of the subject.

D. Additional Points of Emphasis

1. BESRL-provided PI keys could be used as needed during testing.

2. "Change Status" responses were appropriate only for targets falling within overlap area, although all targets were to be reported even though outside common area.

3. No special provisions were made to ensure that order of photos in packets was constant or that subjects proceed systematically through the 10 photos or pairs.

4. Subjects were encouraged to provide measures of individual performance by minimizing communication and subject interaction during and between test periods.

## APPENDIX C--CHANGE STATUS RESPONSE ANALYSIS

The small number of targets representing certain types of change precludes making definitive statements about targets which were Unchanged, Moved, or Replaced. For instance, there were only three "Unchanged" targets in the image sample, and 45.8 percent of the times they were presented they were not detected. "New" targets, of which there were 85, were correctly recognized as such two-thirds of the time and missed one-fourth of the time. "Gone" targets, on the other hand, although more frequent in the test imagery, were correctly recognized less than one-half the time and omitted one-half the time. "Gone" targets are apparently much more difficult under the OR condition for no-experience subjects (see Table C-3). This circumstance is undoubtedly attributable to the nature of the reference material these groups are required to use or to the fact that the no-experience subjects worked with overlays and reports which had been prepared from imagery they had never seen.

"Gone" targets were most frequently detected and categorized correctly under the computer compared condition (CC reference material). It should be remembered, however, that under this condition, the report prepared on the $P_1$ image (which contained all of the "Gone" targets as well as the "Unchanged", "Moved", and "Replaced" targets) was accomplished without a time limit. The effect that limited search time has on the frequency of reporting "Gone" targets can readily be seen by comparing the 5- versus 15-minute conditions for the other reference material conditions. Since the computer was programmed to compare inputs from two independent sources ($P_1$ and $P_2$) and make change status assignments based on the similarities and discrepancies in the two reports, a particularly complete and accurate $P_1$ analysis input would lead to a preponderance of correct "Gone" target assignments, whereas more complete $P_2$ analysis would produce a higher incidence of correct "New" target designations.

When "Unchanged" targets were incorrectly categorized, they were more often reported as "Gone" targets (46.9 percent) than as "New" targets (18.7 percent). They were less frequently thought to be "Moved" targets (15.7 percent) than "Replaced" targets (18.7 percent). The single "Moved" target was very seldom detected and when it was, it was usually incorrectly thought to be a "Gone" target indicating difficulty in detecting and/or recognizing it as the same target on the $P_2$ imagery. Incorrect change status responses for both "New" and "Gone" targets were in the "Unchanged" and "Moved" categories (approximately 90 percent), suggesting that they may be frequently detected on either $P_1$ or $P_2$, but then are incorrectly assumed or perceived to be present on the comparative image sample.

Table C-1

SUMMARY DISTRIBUTION FOR CORRECT, INCORRECT, OMITTED, AND INVENTED TARGET RESPONSES FOR THE FIVE CHANGE STATUS CATEGORIES

| Target Responses (Percent) | Change Status Categories | | | | |
|---|---|---|---|---|---|
| | Unchanged (N = 3)[a] | Moved (N = 1) | New (N = 85) | Gone (N = 97) | Replaced (N = 0) |
| Correct Responses | 37.5 | 3.1 | 68.7 | 43.5 | 0.0 |
| Incorrect Responses | 16.7 | 26.6 | 4.2 | 3.9 | 0.0 |
| Omitted ($E_o$) Targets | 45.8 | 70.3 | 27.1 | 52.6 | 0.0 |
| Cumulative Totals | 100.0 | 100.0 | 100.0 | 100.0 | 0.0 |
| Inventive Errors ($E_i$) (N = 860) | 12.8 | 3.1 | 45.5 | 38.3 | 0.2 |

[a]N = The total number of targets on the ten comparative photo pairs falling into the change status category.

Table C-2

DISTRIBUTION OF TOTAL CHANGE STATUS ERROR RESPONSES ACROSS CHANGE STATUS CONDITIONS

| Change Status Responses ($E_{cs}$) | True Change Status | | | | |
|---|---|---|---|---|---|
| | Unchanged (N = 32)[a] | Moved (N = 17) | New (N = 226) | Gone (N = 242) | Replaced (N = 0) |
| Unchanged | | 11.8 | 25.7 | 54.5 | 0.0 |
| Moved | 15.7 | | 60.2 | 37.2 | 0.0 |
| New | 18.7 | 5.9 | | 0.4 | 0.0 |
| Gone | 46.9 | 70.5 | 5.3 | | 0.0 |
| Replaced | 18.7 | 11.8 | 8.8 | 7.9 | |

[a]N = The total number of change status error responses ($E_{cs}$) for each change status category.

Table C-3

RAW SCORE DISTRIBUTIONS OF CHANGE STATUS RESPONSES FOR TRUE TARGET CONDITIONS

| Subjects and Responses within Time Periods | | Reference Material Conditions | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | CC | | | | | UP | | | | | AP | | | | | OR | | | | |
| | | Change Status[a] | | | | | Change Status | | | | | Change Status | | | | | Change Status | | | | |
| | | U | M | N | G | R | U | M | N | G | R | U | M | N | G | R | U | M | N | G | R |
| **No-Experience** | | | | | | | | | | | | | | | | | | | | | |
| Responses 5 Minutes | U | 4 | 0 | 1 | 20 | 0 | 4 | 0 | 2 | 4 | 0 | 6 | 0 | 4 | 3 | 0 | 1 | 0 | 3 | 3 | 0 |
| | M | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 6 | 8 | 0 | 0 | 0 | 40 | 5 | 0 | 0 | 0 | 35 | 0 | 0 |
| | N | 1 | 0 | 266 | 0 | 0 | 0 | 0 | 145 | 0 | 0 | 0 | 0 | 148 | 0 | 0 | 2 | 0 | 173 | 0 | 0 |
| | G | 3 | 3 | 0 | 246 | 0 | 0 | 0 | 0 | 52 | 0 | 1 | 0 | 0 | 92 | 0 | 0 | 0 | 1 | 18 | 0 |
| | R | 1 | 0 | 0 | 6 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 10 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| Responses 15 Minutes | U | 4 | 0 | 0 | 20 | 0 | 7 | 0 | 3 | 6 | 0 | 10 | 1 | 8 | 7 | 0 | 5 | 1 | 8 | 12 | 0 |
| | M | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 14 | 4 | 0 | 1 | 1 | 10 | 20 | 0 | 0 | 0 | 7 | 15 | 0 |
| | N | 1 | 0 | 280 | 0 | 0 | 0 | 0 | 272 | 1 | 0 | 0 | 0 | 257 | 0 | 0 | 0 | 0 | 244 | 0 | 0 |
| | G | 4 | 3 | 5 | 245 | 0 | 0 | 1 | 4 | 239 | 0 | 0 | 0 | 0 | 220 | 0 | 0 | 0 | 0 | 52 | 0 |
| | R | 1 | 0 | 4 | 7 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **Experienced** | | | | | | | | | | | | | | | | | | | | | |
| Responses 5 Minutes | U | 4 | 0 | 0 | 17 | 0 | 3 | 0 | 4 | 7 | 0 | 5 | 0 | 5 | 9 | 0 | 2 | 0 | 5 | 4 | 0 |
| | M | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 14 | 0 | 0 | 0 | 2 | 6 | 0 | 0 | 0 | 10 | 3 | 0 |
| | N | 0 | 1 | 251 | 0 | 0 | 0 | 0 | 252 | 0 | 0 | 1 | 0 | 195 | 0 | 0 | 1 | 0 | 174 | 0 | 0 |
| | G | 2 | 1 | 0 | 252 | 0 | 0 | 0 | 0 | 157 | 0 | 1 | 2 | 1 | 183 | 0 | 0 | 0 | 1 | 62 | 0 |
| | R | 0 | 0 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Responses 15 Minutes | U | 2 | 0 | 0 | 8 | 0 | 5 | 0 | 3 | 3 | 0 | 6 | 0 | 8 | 5 | 0 | 4 | 0 | 4 | 4 | 0 |
| | M | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 7 | 8 | 0 | 0 | 0 | 1 | 4 | 0 | 2 | 0 | 3 | 3 | 0 |
| | N | 0 | 0 | 267 | 0 | 0 | 0 | 0 | 266 | 0 | 0 | 0 | 0 | 267 | 0 | 0 | 0 | 0 | 281 | 0 | 0 |
| | G | 3 | 0 | 0 | 263 | 0 | 0 | 0 | 0 | 215 | 0 | 0 | 1 | 0 | 231 | 0 | 1 | 1 | 0 | 176 | 0 |
| | R | 2 | 0 | 3 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 1 | 1 | 0 |

[a] Change Status Symbols: U = Unchanged; M = Moved; N = New; G = Gone; R = Replaced.

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| 11. SUPPLEMENTARY NOTES | 12. SPONSORING MILITARY ACTIVITY |
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| | Asst. Chief of Staff for Intelligence<br>Office, Chief of Research and Development |

13. ABSTRACT

The present publication reports on a study of methods of comparing current with prior imagery cover of a given area as means of detecting change in the status of targets in the area. The objective of the research effort, undertaken jointly by personnel of the Boeing Company, the System Development Corporation, and of the INTERPRETER TECHNIQUES Work Unit, USA BESRL, was to investigate the effects of selected procedural variables on the completeness and accuracy with which change in the status of targets is detected. Sixty-four student interpreters from USAINTS, Fort Holabird participated in performing a tactical target change detection task. Sixteen groups (matched on scores on the GT Aptitude Area) of four men each were formed, half of which were designated "experienced"; the other half, "no-experience". Each group performed the target search, target identification, and change detection task under one of 16 experimental conditions. Comparison materials provided were either pairs of unannotated photos, pairs of photos one of which was annotated, or photo overlays plus written reports of earlier coverage paired with a more recent photo. In a fourth procedure, separate analyses of the comparative photos were made and the data subjected to a simulated computer comparison. Each comparative scene was viewed for either 5 or 15 minutes. Change detection performance was evaluated in terms of completeness and accuracy.

Under the 5-minute time limit, computerized comparison produced more complete change detection results than did the other comparative cover analyses, and with about the same degree of accuracy as comparison by an interpreter. The advantage of computer comparison was less marked under the 15-minute time limit. Providing the interpreter with overlay plus a written report on the prior imagery was the least effective of the

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| 14. KEY WORDS | LINK A | | LINK B | | LINK C | |
|---|---|---|---|---|---|---|
| | ROLE | WT | ROLE | WT | ROLE | WT |
| *Target change detection | | | | | | |
| *Comparison methods--imagery | | | | | | |
| *Simulated computer comparison | | | | | | |
| *Comparative cover analyses | | | | | | |
| Aerial surveillance | | | | | | |
| Photographic intelligence systems | | | | | | |
| Laboratory facilities | | | | | | |
| *Task - time analyses | | | | | | |
| Imagery interpretation | | | | | | |
| *Comparative-cover aerial photography | | | | | | |
| *Interpreter performance | | | | | | |

13. ABSTRACT - Continued

comparison methods investigated. Without the actual imagery from the earlier mission, the interpreter has no way of correcting errors in the earlier interpretation. The method also was time-consuming. Interpreter familiarity with the area through preparation of prior imagery reports resulted in enhanced performance only under the 5-minute limit. Results thus point to an advantage in using the computerized comparison procedure in an advanced surveillance system. For maximum operational efficiency, interpreters familiar with a particular area should be assigned to make subsequent comparative cover analysis of the area.