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THE VALUE OF SPECIAL TRAINING AND JOB AIDS FOR IMPROVING UNATTENDED GROUND SENSOR OPERATOR PERFORMANCE

Sterling Pilette and Bill Biggs
HRB-Singer, Inc.

and

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Army Research Institute for the Behavioral and Social Sciences

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Requirement: To determine the value of unattended ground sensor operator training and job aids derived from an analysis of errors and to determine the effect on operator performance of target-activity level and number of sensors used in a string.

Procedure: The training program and job aids were evaluated using the pretest and posttest design with 4 hours of scenarios containing typical target patterns at two levels of target activity generated by 2-, 3-, and 4-

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sensor strings. Operators detected and identified targets and estimated their speed and number.

Results: The individualized training program resulted in significantly improved operator interpretation performance in target detection rights, identification rights, target speed, and target quantity estimation. Use of the job aid (nomograph) significantly improved performance in identification rights, target speed estimation, target quantity estimation, and reporting time. Student acceptance of the individualized training approach and both job aids was high. Operator performance on 3- and 4-sensor strings was 77% detection completeness with virtually no false alarms. Detection of targets was better during low-target activity than during high-target activity. The use of three sensors in a string resulted in the same operator performance as the use of four sensors.

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BATTLEFIELD INFORMATION SYSTEMS TECHNICAL AREA

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FOREWORD

The Battlefield Information Systems Technical Area is concerned with the demands of the future battlefield for increased man-machine complexity to acquire, transmit, process, disseminate, and use information. The research focuses on the interface problems and interactions within command and control centers and deals with such areas as topographic products and procedures, tactical symbology, information management, user-oriented systems, staff operations and procedures, and sensor systems integration and utilization.

One area of special interest is that of human factors problems of the presentation and interpretation of surveillance and target acquisition information. One relatively new source of intelligence information is remote monitoring of the battlefield using seismic, acoustic, and magnetic unattended ground sensors (UGS). When these remote sensors are activated by enemy personnel or vehicle movement, a monitor display located behind our lines indicates the activity. The operator can derive from this display not only the presence of the enemy but such information as the direction and speed of convoys and personnel, the number of vehicles in a convoy, and the composition of the convoy, e.g., armored versus wheeled vehicles. The present publication discusses the development and evaluation of a training test and job aids which significantly improve operator performance by correcting known deficiencies. In addition, the number of sensors in a string and level of target activity was varied in the research to determine their effects on operator performance.

Research in the area of sensor systems integration and utilization is conducted as an in-house effort augmented through contracts with organizations selected for their unique capabilities and facilities for research on sensor systems. The present study was conducted with personnel from HRB Singer, Inc. under contract DAHC 19-73-C-0024 with program direction from Mr. Cecil D. Johnson. The effort is responsive to requirements of Army Project 2Q662704A721 and to special requirements of the Assistant Chief of Staff for Intelligence.

The cooperation of the participating personnel at Fort Bragg, N.C., is appreciated, especially that of Maj. Gronich. A special note of thanks is due to Sgt. D. Chiodini, chief of the Read-out Section of the UGS Division, U.S. Army Intelligence Center and School (USAICS), Fort Huachuca, Ariz., for his expert technical assistance.

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THE VALUE OF SPECIAL TRAINING AND JOB AIDS FOR IMPROVING UNATTENDED GROUND SENSOR OPERATOR PERFORMANCE

BRIEF

Requirement:

To determine the value of unattended ground sensor operator training and job aids derived from an analysis of error sources and the effect on operator performance of target activity level and numbers of sensors used in a string.

Procedure:

Based on an analysis of operator errors made in a previous study, a training program and two job aids were developed. To test the value of the training and one of the job aids (measuring device), two 2-hour scenarios were constructed for pre- and posttraining evaluation. Typical target patterns at two levels of target activity and three levels of sensor string size were systematically varied within 30-minute segments. Authentic fixed-wing and helicopter activity, artillery shell bursts, and random noise were included to simulate operational, nontarget activations. The second job aid, a nomograph, was evaluated using the pretest and posttest design. Two special tests requiring only the measurement and computations necessary for estimates of speed and enemy number(s) were developed for this purpose.

Twenty school-trained Army enlisted men (UGS (unattended ground sensor) operators), were given test procedure training and a short refresher in UGS interpretation. Two 10-man groups were formed and each was given different scenarios for the pretest; these were then switched for the posttest. The training program--given between the pretest and posttest--stressed individualized instruction including self-pacing, immediate feedback, expert assistance when needed, and guaranteed student-mastery using criterion testing. One job aid, an UGS ruler for accurately measuring the length of activation patterns, was part of the training exercise. The other job aid (a nomograph), which had been developed to simplify arithmetic calculations and decimal point placement, was tested separately after the above training and posttest.

Findings:

The individualized training program resulted in significantly improved operator interpretation performance in target detection rights,

identification rights, target speed, and target quantity estimation. Use of the nomograph significantly improved performance in identification rights, target speed estimation, target quantity estimation, and reporting time. Student acceptance of the individualized training approach and of both job aids was high. Operator performance on 3- and 4-sensor strings was 77% detection completeness with virtually no false alarms. Detection of targets was better during low target activity than during high target activity. Use of three sensors in a string resulted in the same operator performance as use of four sensors.

Utilization of Findings:

The lesson materials together with the individualized training approach should be used to provide review and on-the-job training to operational field personnel and should also be integrated into the UGS course at USAICS, Fort Huachuca, Ariz.

The nomograph should be included as standard issue with operational event recorders and should be taught at UGS course USAICS and given to each graduate to take with him to his assigned unit. A credit-card size UGS ruler should be issued to everyone involved in monitoring UGS target activation.

To increase timeliness, the UGS operator should send forward a detection report based on two sensors (or more, if doubt exists) with a followup report giving target type, speed, and number.

A research study controlling on target difficulty and comparing 2 versus 3 versus 4-sensor strings should be done to provide data for determining the most efficient string size.

During high-target-activity conditions, operator reports should be considered as greater underestimates than during low-target-activity periods.

THE VALUE OF SPECIAL TRAINING AND JOB AIDS FOR IMPROVING UNATTENDED GROUND SENSOR OPERATOR PERFORMANCE

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THE VALUE OF SPECIAL TRAINING AND JOB AIDS FOR IMPROVING UNATTENDED GROUND SENSOR OPERATOR PERFORMANCE

BACKGROUND

As discussed in the ST 30-20-1 Army manual (U.S. Army, 1971), in September 1966 the Secretary of Defense directed the armed forces to develop an infiltration interdiction capability to assess vehicle and personnel flow in Southeast Asia. The anti-infiltration capability that was developed centered on a group of remotely monitored electronic sensor devices called unattended ground sensors (UGS).

UGS provides the Army's battlefield surveillance and target acquisition system with another versatile capability, that of obtaining real-time information about enemy movement. Most UGS in use today are seismic, others are magnetic, acoustic, electromagnetic, and passive infrared. They can be hand implanted, air implaced, or mortar and artillery delivered. UGS systems are recognized as effective battlefield assets, and they are expected to become an important source of combat intelligence for many situations.

Even though UGS have already demonstrated their value in operational and test situations (U.S. Army, 1971 and 1972), their information potential is far greater than has been realized heretofore. Controlled tests show that varying degrees of misleading and inaccurate information are being supplied by both the sensor equipment and human operators (Martinek, Pilette, and Biggs, 1978; U.S. Army, 1970; and West, 1973). Appropriate research and development can minimize such deficiencies.

Systematic field experimentation shows that UGS can be unreliable at times. One reason is lack of understanding and anticipation of environmental influences upon sensor response characteristics. For example, in a field test conducted under dry-season terrain conditions, considerable site-to-site variation occurred in seismic response characteristics due to soil surface conditions, vegetation ground covers, and background noises (West, 1973).

Variable sensor response characteristics make the job more difficult for the sensor operator, and human error has definitely contributed to inaccurate and misleading information output. The problem is to isolate techniques that will reduce human error in UGS target reporting. Although a number of diverse factors may make UGS operator performance less than optimal, the more prominent problems can be attacked directly through specialized training, operator techniques, and job aids.

OBJECTIVES

1. To identify problem areas experienced by UGS operators, develop specialized training materials to control these difficulties, and empirically demonstrate the effectiveness of such training.

2. To determine if two job aids (nomograph and UGS ruler) can improve the measurements and computations of UGS monitors.

3. To decrease the time needed for UGS reporting.

4. To determine parameters of performance under several operational conditions.

5. To determine the changes in performance due to the number of sensors used in a string.

METHOD

Population and Sample

The population of concern is the UGS operator (MOS 17M20) who has been school trained at the U.S. Army Intelligence Center and School (USAICS), Fort Huachuca, Ariz. Twenty enlisted personnel MOS 17M20 of the 82nd Airborne Division stationed at Fort Bragg, N.C., served as operators. Although they had been in the field for several months, they had not interpreted UGS activations using the operational display (the RO376 event recorder).

Apparatus

Ten modified Esterline Angus Chart Inspectors were used to display the pretest and posttest scenarios (RO376 event recorder plots). Each was mechanically adjusted to drive the plots at the same speed (12 inches per hour) as the RO376 event recorder (U.S. Army, 1969). A display housing was placed on each mechanism to reduce its viewing area to that of the RO376. Thus, the test scenarios were presented at the same speed and format as in a field situation.

Training Requirements

Review. The first step in the identification of problem areas in UGS monitor performance involved a review of training being conducted at Fort Huachuca. Training manual documentation was reviewed (U.S. Army, 1971, 1972) and interviews were held with senior instructors to identify specific areas of substandard performance. Student performance

data, collected during an earlier experiment (Martinek, Pilette, and Biggs, 1978), were analyzed in an effort to document and categorize factors leading to human error in UGS monitor performance. Based on these efforts, three major problem areas were identified.

Target Detection and Identification. This category deals with the operator's ability to detect and identify targets. The operators detected fewer targets when these targets activated 2-sensor strings as compared to 3- and 4-sensor strings. Also, lower detection completeness (detection rights divided by total number of targets) occurred during high target activity as compared to low target activity. Also, approximately 20% of the targets detected were not identified correctly as to vehicle or personnel. Following the pattern established by the detection results, fewer targets were identified when they were activated with 2-sensor strings and during high target activity.

Column-Length Formula Calculations (see Appendix A). This category deals with the ability of the operator to use the column-length formula with target patterns that he has detected. A sensor activation pattern is composed of short horizontal lines occurring within a specified time interval (determined by a sensor's inhibit time). They are displayed on the appropriate channel of the plot paper which serves as the readout sheet for the operator. The formula provides an estimated target speed and number of targets in a convoy. Some specific factors noted were (1) incorrect placement of the endpoints of sensor activation patterns for measuring TT_1 and TM (see page 10 for definition); (2) inaccurate estimations of TT_1 and TM measurements, even if the activation end-points are not ambiguous; (3) arithmetic errors in multiplication, division, and decimal point placement; and (4) confusion in computing the combined detection range (CDR) value and in selecting the arithmetic function to use with it.

Nonseismic and Confirmatory Sensors. This category deals with the inability of the operator to optimally use information presented by the following sensors when these sensors were part of a deployed sensor string: electromagnetic intrusion detector (EMID), magnetic intrusion detector (MAGID), and directional infrared intrusion detector (DIRID).

Development of Training Materials and Job Aids

Although a number of training requirements could be satisfied by the development of content in specific subject matter areas, analysis of training requirements revealed a need for job aids that would assist the UGS monitor in making measurements and calculations relating to the column-length formula.

The following content lessons were outlined and developed.

a. Lesson 1--UGS Ruler (training in the use of this job aid).
Objective--To improve accuracy in measuring TT_1 and TM values by using a calibrated ruler.

b. Lesson 2--2-Sensor Strings and Formula Review.
Objective--To improve detection capability using 2-sensor strings and to provide recall or basic training in computing the column-length formula.

c. Lesson 3--End-Points.
Objective--To standardize and improve estimations of end-point locations in the case of irregular activation patterns.

d. Lesson 4--Column-Length Quantity.
Objective--To review and to provide more extensive training in interpreting variations in quantity values.

e. Lesson 5--Irregular Activation Patterns.
Objective--To improve the detection and information extraction from target patterns that do not have the classical, clear-cut shape (stair step).

f. Lesson 6--EMID.
Objective--To increase information extraction potential of the EMID sensor through familiarization with its activation patterns.

g. Lesson 7--MAGID.
Objective--To illustrate the MAGID capability and limitations in providing information concerning the number of targets in a column.

h. Lesson 8--DIRID.
Objective--To increase the information potential of the DIRID sensor through familiarization with its activation patterns.

The error analysis indicated a need to (a) accurately measure the elapsed time of target activation patterns that are formed from UGS and (b) reliably perform arithmetic functions and decimal point placement. To satisfy the former requirement, an UGS ruler was developed that could be laid down on the RO376 plot paper to permit activation patterns to be measured consistently and accurately to the nearest 1/10 minute. Although use of the UGS ruler was taught in Lesson 1, it was also included as a part of the nomograph developed to satisfy the second need above. Thus, the operator would need only one instrument for measurement, arithmetic calculations, and decimal point placement as required by the column-length formula.

The nomograph is shown in Figure 1. The abscissa is the distance between the seismic sensors (in meters). The ordinate is target activation time (in minutes). A slide indicator or tongue, consisting of a clear plastic rectangle 3/4 in. x 10-1/2 in. with a black line running through the long axis, is anchored by a grommet in the upper left-hand corner from where it pivots. For computing target speed, $\frac{D}{TM}$ of the column-length formula, the slide indicator is pivoted until the black line is over the intersection of the activation time and the sensor distance. The target speed can then be read from the meters-per-minute scale at the bottom and right-hand side of the nomograph.

With the slide indicator remaining in the same position, the nomograph can then be used to compute $\frac{D}{TM}$ (TT_1) of the formula. This is done simply by locating the intersection of the black line on the slide indicator with the TT_1 time measurement, and then reading the distance value from the meters scale. The difference between this value and the CDR is the target column-length. The nomograph, therefore, can be used for division and multiplication. The Fort Huachuca training personnel have developed additional uses for the nomograph in various applications.

Design of the Training System

With the training content determined, the next step was to design the training system with which to implement the content. The training system was designed to allow each individual to proceed at his/her own pace, test knowledge after short segments (lessons) of instruction, obtain immediate feedback on mastery of the content, and receive expert assistance when needed. The training system is described below in terms of its three major components: materials, personnel, and lesson sequence.

In the self-paced training system that was designed, the content was organized into distinct lessons, each covering a short segment of instruction. Each lesson contained a Lesson Sheet, a Practical Exercise Sheet, a Practical Exercise Answer Key, a Criterion Exercise Sheet, and a Criterion Exercise Answer Key.

The Lesson Sheet was divided into three sections: Objective, Purpose, and Concept. The Objective section stated what the operator should be able to do at the end of the lesson, the Purpose section stated the importance of the lesson, and the Concept section contained the instructional materials with examples. A sample lesson sheet is shown in Appendix A.

The Practical Exercise Question Sheet contained questions on the material discussed on the Lesson Sheets. These questions were intended to allow the operator to test his mastery of the concepts in the lesson.

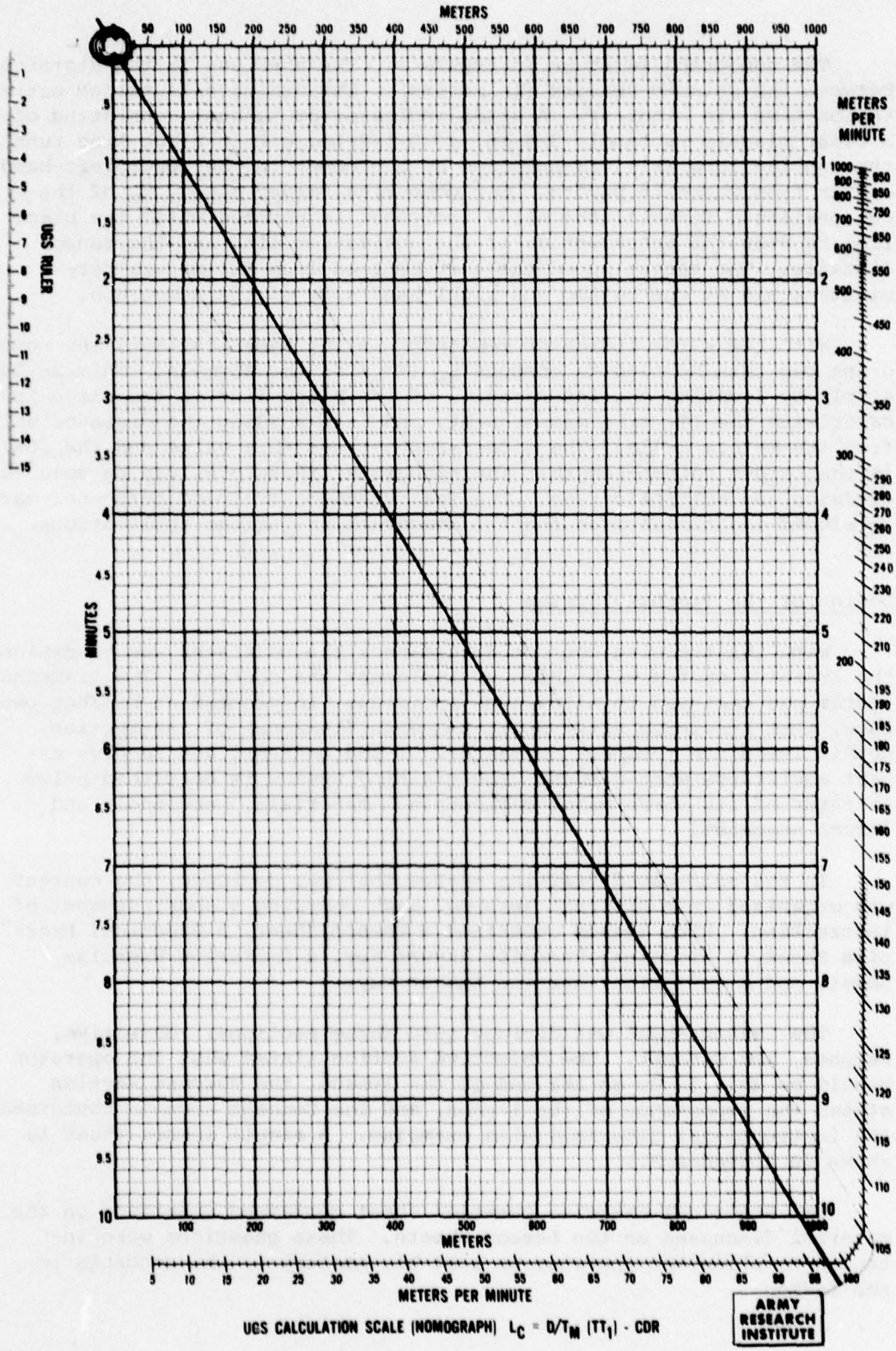

Figure 1. Job aids--UGS ruler combined with nomograph.

The Practical Exercise Answer Key provided the operator with the correct answers to the questions and allowed him to check his own knowledge. The operator could restudy the lesson sheet if he did not do satisfactorily.

The Criterion Exercise Sheet contained questions relating to information on the Lesson Sheet. These questions tested the same thing as the practical exercise questions and were the final check for mastery before going on to the next lesson.

The Criterion Exercise Answer Key enabled the training monitor to evaluate the operator's performance on the Criterion Exercise. If the operator performed within preestablished criterion levels, he or she was given the next Lesson Sheet. If not, he/she was sent back for additional review or to an instructor for individualized help.

In this training system, there were three test monitors and one subject matter expert. They helped the operators and monitored their progress through the system. For normal usage in the field the material could be bound into a booklet and monitoring would require only one person (3, below):

1. One test monitor was at Station 1 to control handout of the Lesson Sheet and score the Criterion Exercises.

2. Two test monitors were at Station 2 to control all activities having to do with the Practical Exercises.

3. The subject matter expert was at Station 3 to provide subject matter assistance whenever it was needed.

The operators were required to follow five basic steps to complete each lesson:

1. Read the Lesson Sheet for comprehension.

2. Answer the Practical Exercise Questions.

3. Check the answers with the Answer Key and reread the Lesson Sheet if necessary.

4. Answer the Criterion Exercise Questions.

5. Have the answers checked with the test monitor. If the criterion was met, the operator was allowed to progress to a new lesson; if the criterion was not met, the operator was asked to review the Lesson Sheet and Practical Exercises and/or confer with the subject matter expert and then rework the Criterion Exercise.

Development of the Test Scenarios

In order to assess objectively the performance of the operators, scenarios were developed from scenarios used in a previous study (Martinek, Pilette, and Biggs, 1978). These were developed from magnetic tapes of typical activations produced by personnel, tracked and wheeled vehicles, and typical noise such as artillery and aircraft collected during Project 1030 and BASS III tests conducted at the Modern Army Selected Systems Test and Evaluation (MASSTER) project, Fort Hood, Tex. (U.S. Army, 1970 and 1972). Because these were controlled exercises, target location and time were known and could be related to sensor activations.

Eight 30-minute "high-noise" segments were selected: four segments for each of two scenarios. These scenarios were matched with respect to string size and target activity. Two of the segments in each scenario contained three targets each (low activity) and two contained six targets each (high activity). Sensor string size was systematically varied, i.e., in the three-target case, one target involved a 2-sensor string, one involved a 3-sensor string, and one involved a 4-sensor string. In the six-target case, these were doubled. Targets were selectively arranged within each 30-minute period to provide variation and balance.

High-noise means that the segments simulated a battlefield environment containing typical activations caused by fixed-wing and helicopter activity, live artillery firing, weather activity, and unreliable (noisy) sensors. These activations were not eliminated when they occurred with the original target patterns and, in many cases, were added to scenario segments to obtain a reasonable balance in amount and type across all the segments.

Training Validation Design

The effectiveness of the training materials was assessed by means of a pretest/posttest comparison of UGS monitor performance on operationally realistic sets of scenarios using simulated RO376 event recorders. The effectiveness of the job aid (nomograph) was assessed by a pretest/posttest comparison of 10 problems requiring the operators to derive target speed and quantity from typical activation patterns.

Independent Variables. The independent variables planned for analysis are defined below.

1. Sessions--Pretest versus posttest. The pretest was administered during Session I and the posttest was administered after training (Session II).

2. Sensor String Size--Two-sensor strings versus 3-sensor strings versus 4-sensor strings.

3. Target Activity--Low target activity (3 per 30 minutes) versus high target activity (6 per 30 minutes). A target was defined as one or more vehicle(s) or person(s) traveling in a column on a trail.

4. Scenarios--Two 2-hour scenarios were matched with respect to string size and target activity. They were administered in a counterbalanced order as either pretest or posttest. Equivalent scenarios were not guaranteed because different amounts of noise were present and different targets were used in each scenario. The scenario variable was of interest mainly to increase the sensitivity of the statistical analysis and provide data for future scenario development.

5. Groups--The 20 operators were randomly assigned to two groups to control for scenario effects by counterbalancing. Thus, one group received scenario "A" during the pretest and the other group received scenario "B"; the reverse was used for the posttest.

The independent variables were analyzed by using a mixed-model analysis of variance design. By this design, individual differences are controlled across sessions (training effects) and all important variables analyzed are within-subject comparisons. The three factors of groups, sessions, and scenarios were counterbalanced in a Latin square, and as a result, interactions of these factors could not be obtained. While the main effect of sessions alone would indicate the effectiveness of the self-paced training materials, the main effects of sensor string size, target activity, and the higher order interactions were included in the detection and identification analysis mainly to determine the specific areas of usefulness.

In a previous study, it was shown that UGS operator detection and identification rights were significantly lower with 2-sensor strings than with 3- or 4-sensor strings (Martinek, Pilette, and Biggs, 1978). In addition, percentage completeness on high-target-activity scenario segments was significantly lower than on low-target-activity scenario segments. The self-paced training materials were developed to help improve performance with the 2-sensor string condition. The overall effect of the training should also help to improve performance in the high-target-activity condition more than in the low-activity condition, because there is more room for improvement and more weight was given to errors in the high-activity condition in the determination of problem areas. Thus, interaction effects with these variables and sessions were expected.

Dependent Variables. For the assessment of the training materials, nine separate dependent measures were planned. The first three dealt

with the overall measures of performance; the last six were related to special aspects of the operator's job.

Using the independent variables listed above, separate analyses of variance were planned for the following dependent variables:

Detection rights--If an operator reported an activation pattern on the display that was a valid target, the response was classified as a detection right. This variable is perfectly correlated (for most variables) with detection completeness because completeness is a ratio of the targets detected to the total number of targets present. Percentage completeness figures are given where they have special meaning.

Wrongs (false alarms) --If an operator reported an activation pattern on the display that was not a valid target, the response was classified as a false alarm.

Identification rights --If, in addition to detecting a valid target, the operator classified it correctly by type (personnel or vehicle), the response was also classified as an identification right.

The following four dependent measures relate to the ability to use the formulas in arriving at additional intelligence information once a target has been detected.

TT_1 --Total time (in minutes) of the first sensor activation pattern of a sensor string.

T_M --Time difference (in minutes) between the midpoint of the first sensor activation pattern and the midpoint of the second sensor activation pattern.

Speed --Estimated speed (meters/minutes) with which the target moved through the sensor string. Speed is usually calculated from time (T_M) and the distance between two sensors.

Quantity --Number of targets estimated to be in the target column; obtained by dividing the total length of the column by the estimated distance between targets.

The final two dependent measures were

Reporting time --Time between target detection and completion of the report as written by the operator.

Confidence --The operator's estimates on a four-unit scale as to how confident he or she is that the activation pattern he/she is reporting on is a valid target.

Job Aid (Nomograph). The evaluation of the job aid involved giving paper-and-pencil tests in which 10 target activation problems were presented on the pretest and posttest. The operator did not detect targets but only made the necessary measurements and calculations necessary for reporting additional intelligence information (speed and quantity). The posttest was prepared by randomly rearranging the targets of the pretest and changing the numerical values of the distances between the sensors and sensor detection ranges. Performance was compared on the following dependent measures: TT_1, T_M, speed of target, target type, length of column, quantity, and reporting time.

Criteria for Scoring Formula Dependent Variables. The intervals of correctness were established by selecting and setting values above and below the established school solutions for TT_1 and TM. The criterion for accepting TT_1 and TM values for the individualized training was within 2/10 of a minute above and below the established school solution. The result of accepting a range of values from TM introduced a range of values for speed. Likewise, accepting a range of values for TT_1 introduced a range of values for length of column and quantity. It was necessary to compute ranges for each target for scoring purposes.

The objective of the job aid evaluation was to assess the worth of the nomograph/UGS ruler combination, using the highest standards that could be needed in the field. The range of acceptance, therefore, for the pretest and posttest of the job aids was set at 1/10 minute above and below the established school solution of TT_1 and TM.

Test Procedure

The test plan covered a 4-day period, as shown in Figure 2. During the first day, 10 operators received test procedure training plus the pretest in the morning: 10 received the same in the afternoon. This procedure was necessary because only 10 RO376 simulators were available. For both the morning and afternoon, five operators received Scenario A and five received Scenario B for the pretest.

During the second day, all 20 operators received the eight lessons of individualized training. This training did not require the use of the drive mechanisms. At the completion of the training, all operators completed a course evaluation questionnaire. The questionnaire provided a measure of operator acceptance of the materials and the training system. In addition, this information and the operator course performance data provided input for future revisions of the course material.

Day 1	Test procedure and pretest
7:30 a.m. - 9:30	Training on test procedure with the RO376 simulator for 10 operators.
10:00 - 12:00	Pretest--Each operator interpreted 18 targets in a 2-hour scenario using the RO376 event recorder simulator. Five operators received Scenario A and five operators received Scenario B.
1:00 - 3:00	(Same as 7:30 - 9:30)
3:30 - 5:30	(Same as 10:00 - 12:00)
Day 2	Individualized, self-paced training
8:40 a.m. - 12:00	Four lessons--hard copy--20 subjects
1:00 - 4:00	Four lessons--hard copy--20 subjects
4:00 - 5:00	Student training evaluation questionnaire--20 operators
Day 3	Posttest
9:00 a.m. - 11:00	Posttest--Each operator interpreted 18 targets in a 2-hour scenario using the RO376 event recorder simulator. Five operators received Scenario A and five received Scenario B. Operators and scenarios were switched from the pretest.
2:00 - 4:00	Same as above for second group
Day 4	Nomograph, pretest, training, and posttest
7:30 a.m. - 8:30	Pretest--hard copy format--20 operators
9:00 - 11:00	Training--lecture/discussion--20 operators
1:00 - 3:00	Posttest--hard copy format--20 operators

Figure 2. Test administration schedule.

The posttest was administered on the third day. During the morning, the five operators who received Scenario A as the pretest now received Scenario B, and those who initially received Scenario B now worked through Scenario A. The same procedure was followed in the afternoon with the remaining 10 operators.

During the final day, all 20 operators received a pretest in the morning, training on column-length formula calculations using the nomograph, and a posttest in the afternoon.

For the individualized training, Appendix B presents the monitor instructions for the (1) initial test procedure training, (2) pretest and posttest training, and (3) actual training administration procedure. The job aid (nomograph) monitor instructions are not provided because they were given in a spontaneous lecture-discussion approach. For the nomograph training, a series of practical problems was presented to and solved by the class.

RESULTS AND DISCUSSION

Overall Performance Measures

Detection Rights. The following variables and interactions are of primary importance and are discussed in the order given: sessions, string size, sessions x string size, target activity, and sessions x target activity. Table 1 presents the training experiment analysis of variance results for detection rights. Of most interest is the significant difference (.01 level) found for the sessions variable. Out of a possible 18 rights, the average operator's correctness for the pretest (Session I) was 10.4 rights while that for the posttest (Session II) was 12.3 rights. This represents an 18% improvement or about one target per operator per hour and demonstrates the effectiveness of the training. Appendix C presents a discussion of why this increase is attributable to training as opposed to a practice effect.

The string-size variable (Table 1) is significant at the .01 level. Out of a possible 6 rights for each string size, the 2-sensor strings resulted in 2.6 rights, the 3-sensor strings resulted in 4.7 rights, and the 4-sensor strings resulted in 4.1 rights. The significantly fewer target detections when using 2-sensor strings agrees with the results of a previous study (Martinek, Pilette, and Biggs, 1974).

The interaction of sessions and sensor string size is nonsignificant, suggesting that the increases in performance for the three string sizes (from Session I to Session II) are similar. However, individual statistical tests conducted on each sensor string size for differences between sessions indicates that this condition is true for the 3-sensor and 4-sensor string sizes but not the 2-sensor string size ($t = 2.61$, $df = 19$, $p = .05$). The average scores for this interaction are presented in Table 2.

Table 1

Analysis of Variance Table for Detection Rights

Source	df	SS	MSS	F ratio	Sig. level
Between-subjects	19	30.184			
Groups	1	.417	.417	.252	NS
Error	18	29.767	1.654		
Within-subjects	220	213.000			
Sessions	1	6.0166	6.017	16.395	.01
String size	2	45.0333	22.517	61.354	.01
Session x string size	2	1.2334	0.6167	1.680	NS
Target activity	1	48.600	48.600	132.425	.01
Sessions x target activity	1	1.6667	1.667	4.542	.05
String size x target activity	2	12.7000	6.350	17.302	.01
Scenario	1	12.1500	12.150	33.106	.01
Scenario x target activity	1	5.4000	5.400	14.714	.01
Scenario x string size	2	0	0.000	0.000	NS
Scenario x string size x target activity	2	5.200	2.600	7.084	.01
Session x string size x target activity	2	0.233	0.116	0.316	NS
String size x groups	2	1.7334	0.867	2.362	NS
Target activity x groups	1	0.000	0.000	0.000	NS
String size x target activity x groups	2	0.4000	0.200	0.545	NS
Error (w)	198	72.633	0.367		
Total	239	243.184			

Table 2

Mean Number of Detection Rights by Session and Sensor String Size

	2-sensor	3-sensor	4-sensor	Sum
Session I	2.1	4.5	3.8	10.4
Session II	3.1	4.8	4.4	12.3
Average	2.6	4.7	4.1	

One of the objectives of the training was not only to increase the number of targets detected across all the string sizes, but especially to increase the number of targets detected with 2-sensor strings. As shown in Table 2, the number of targets detected with 2-sensor strings did increase from 2.1 to 3.1. The latter value, however, is still well below the corresponding figures for the 3- and 4-sensor strings (4.8 and 4.4 respectively) indicating that this objective was not completely satisfied. One obvious possibility is that 2-sensor strings are more difficult to interpret. This result reinforces the validity of the doctrine calling for three or more sensors in a string.

The target activity variable is significant; each operator detected, on the average, 4.4 targets during low target activity and 7.1 during high activity. These figures are based on a possible total of 6 targets for the low-activity and 12 for the high-activity condition. Interpretation of all experimental effects involving the target activity variable must consider that twice as many targets are detectable in the high-target-activity condition as in the low. Thus, significant difference in detection rights was expected. Of more importance is the detection completeness of targets detected in each activity condition. During low target activity, 72% of the targets were detected but during high target activity only 59% were detected, a difference which is statistically significant ($t = 4.94$, $df = 19$, $p < .01$).

The interaction of sessions and target activity is significant, which suggests that the increases in performance for the two target activity conditions from Session I to Session II are different. Individual statistical tests indicate that the increase in performance is attributable to the high-target-activity condition ($t = 2.18$, $df = 19$, $p < .05$). The raw score values for this interaction are presented in Table 3, along with completeness scores reported in parentheses.

Table 3

Mean Number of Detection Rights and Completeness by Session and Target Activity

	Low target activity	High target activity	Sum
Session I	4.1 (68%)	6.3 (53%)	10.4
Session II	4.6 (76%)	7.8 (65%)	12.3
Average	4.4	7.1	

One of the objectives of the training was to increase the completeness of targets detected, especially during high target activity. As shown in Table 3, the significant completeness increase from 53% to 65% satisfied this objective. This latter figure, however, is still below the corresponding figure for the low-activity condition (76%). These results indicate that the training was effective in increasing performance, predominantly in the high-target-activity condition.

The string size by target activity interaction presented in Table 4 is significant at the .01 level. Thus, although there are large differences in the mean number of detection rights in the 3- and 4-sensor strings, there is only a small difference in the 2-sensor string. When these figures are corrected for the different numbers of targets in the high- and low-activity conditions, i.e., completeness, the effect on operator performance is clearer. As first observed in a previous study (Martinek, Pilette, and Biggs, 1974), completeness is lower for all sensor string sizes in the high-activity condition, but the significant interaction indicates that, as the number of sensors in the string becomes smaller (i.e., from 4 to 2), it becomes more difficult for a monitor to detect targets during high target activity as opposed to a low target activity. For the 4-sensor condition, a 4% difference exists between the low- and high-activity conditions; for the 3-sensor condition, the difference increases to 13%, and for the 2-sensor condition the difference increases to 23%.

These results should be interpreted with caution. The poorer performance associated with the 2-sensor string condition may be due to a combination of a disproportionate personnel/vehicular target ratio and various conditions prevailing at the time the target activation data were collected. In general, personnel do not produce as good an activation pattern as do vehicles. The target types for the 2-sensor string condition were 5 personnel, 6 vehicles, and 1 combination; for the 3-sensor string condition target types were 3 personnel, 8 vehicles, and

Table 4

Mean Number of Detection Rights and Completeness by String Size and Target Activity

	2-sensor	3-sensor	4-sensor	Sum
Low-target activity	2.4 (59%)	3.5 (86%)	2.9 (71%)	8.7
High-target activity	2.9 (36%)	5.9 (73%)	5.4 (67%)	14.0

1 combination; and for the 4-sensor string condition target types were 2 personnel and 9 vehicles. In addition, because all personnel target activations were collected during the BASS III tests (U.S. Army, 1970) and all vehicular target activations were gathered during the Project 1030 tests (U.S. Army, 1972) with a 2-year interval separating these exercises, differences in equipment reliability, implantation techniques, ground location, weather, and soil type could have had a marked influence on target presentation quality and hence upon operator performance. Thus, the differences found for string size may be due to differences in the level of target difficulty.

The scenario variable is significant at the .01 level, which indicates that Scenario A, with an average of 5 rights, was more difficult than Scenario B, with an average of 6.4 rights. Moreover, the significant interaction between scenario and target activity (.01 level) indicates noticeably lower performance (5.9) in the high-target-activity condition of Scenario A (see Table 5). Although not important to the objectives of this evaluation, a thorough analysis of the causes of this outcome could be useful for future scenario development.

The triple interaction of string size, scenarios, and target activity is significant at the .01 level. The mean number of rights by condition is presented in Table 6.

Table 6 reveals more detailed information concerning significant scenario differences. The scenario and target activity interaction seen in Table 5 indicate that the high-activity condition of Scenario A contained more difficult-to-detect targets. This is especially true of the 2-sensor string condition within the high-activity condition of Scenario A. However, this conclusion and others which can be drawn do not have a direct bearing on the objectives of the study and are important only for future scenario development. All the other interactions tested were found to be not significant.

Table 5

Mean Number of Detection Rights by Scenario and Target Activity

	Scenario A	Scenario B	Sum
Low-target activity	4.1	4.6	8.7
High-target activity	5.9	8.2	14.1
Average	5.0	6.4	

Table 6

Mean Number of Detection Rights by String Size, Scenario, and Target Activity

	Low target activity		High target activity	
String size	Scenario A	Scenario B	Scenario A	Scenario B
2-sensor	1.3	1.1	.9	2.0
3-sensor	1.5	2.0	2.7	3.2
4-sensor	1.3	1.6	2.4	3.0
Average	1.4	1.6	2.0	2.7

Wrongs (False Alarms). Of major interest to this study is the small number of false alarms: only three occurred during Session I and seven during Session II, too few for conducting an analysis of variance. The false alarms were distributed in a random fashion across eight operators. Because of the randomness with which the errors were committed, it is not possible to draw generalizations concerning the causes for false alarms.

The small number of false alarms that occurred in this study represents a sharp contrast to the large number of false alarms reported in a multidisplay comparison study using similar scenarios (Martinek, Hilligos, and Lavicka, 1978). In the present study the average number

of false alarms per 2-hour scenario was .2 while that for the RO376 from the multidisplay study was 5.6. Such a large difference, even though similar scenarios were used, could be caused by differences in (1) instructions (set) or context of the study (comparison of displays versus training), and/or (2) school orientation on accuracy of target reporting. The latter reason is probably more significant, because the average operator in this study had graduated (several months since) from the U.S. Army UGS school. The Army school typically uses classical patterns (stairstep shapes) for practical exercises, and this may automatically ingrain accurate target-reporting habits among the trainees. They are less likely to make errors of commission, but they may be more likely to make errors of omission.

The multidisplay study used 12 Navy personnel who had been trained at another UGS school but, perhaps more important, had been on the job for several years and had received field experience on several maneuvers. These operators committed more errors of commission, but they also detected more targets on the average, which may reflect the Navy's emphasis on completeness.

Identification Rights. Table 7 presents the analysis of variance results for identification rights. Of most interest is the significant difference (.01 level) for the sessions variable. The average operator's identification rights score for the pretest session was 8.3 while that for the posttest session was 10.9. This represents an average improvement for each operator of 2.55 targets or a 31% gain over pretest performance. This is a greater increase than would be expected from the detection results, which showed an 18% improvement. The identification improvement of 31% seems to indicate that the training was more effective in improving target identification than it was for improving target detection, because detection improvement was only 18%. However, identification completeness (the ratio of targets identified to those detected) indicates that there are no significant differences between Session I and Session II.

The string-size variable is significant. Table 8 shows that with 6 targets possible for each string size, operators identified 2.2 of the targets activating the 2-sensor strings, 3.9 of those activating the 3-sensor strings, and 3.5 of those activating the 4-sensor strings.

The interaction of sessions by string size in Table 8 is nonsignificant, which suggests that the increases in performance from Session I to Session II for the three string sizes are similar.

Table 7

Analysis of Variance Table for Identification Rights

Source	df	SS	MSS	F ratio	Sig. level
Between-subjects	19	34.7125			
Groups	1	7.7041	7.7041	5.1344	.05
Error	18	27.0084	1.5005		
Within-subjects					
Session	1	10.8375	10.8375	25.2740	.01
String size	2	34.8083	17.4042	40.5882	.01
Session x string size	2	0.9250	0.4625	1.0786	NS
Target activity	1	22.2041	22.2041	51.7820	.01
Session x target activity	1	1.8375	1.8375	4.2852	.05
String size x target activity	2	6.3084	3.1542	7.3559	.01
Scenario	1	5.1041	5.1041	11.9032	.01
Scenario x target activity	1	2.6043	2.6043	6.0735	.05
Scenario x string size	2	0.8584	0.4292	1.0009	NS
Scenario x string size x target activity	2	4.7582	2.3791	5.5483	.01
Sessions x string size x target activity	2	0.0250	0.0125	0.0292	NS
String size x group	2	11.4084	5.7042	13.3027	.01
Target activity x groups	1	1.2043	1.2043	2.8085	NS
String size x target activity x groups	2	1.3082	0.6541	1.5254	NS
Error (w)	198	84.8916	0.4288		
Total	239	222.796			

Table 8

Mean Number of Identification Rights by Session and String Size

	2-sensor	3-sensor	4-sensor	Sum
Session I	1.7	3.7	3.0	8.3
Session II	2.7	4.2	4.0	10.9
Average	2.2	3.9	3.5	

Identification completeness (i.e., the ratio of the number of targets identified to those detected) for this interaction is shown in Table 9. There are no significant differences between Session I and Session II. Individual t-tests were computed for each string size to test the significance of the difference between the sessions means. The values for the 2-, 3-, and 4-sensor strings were 1.66, 1.07, and 1.67 respectively (n = 9). The results indicate that once a target was detected, the sensor string size was immaterial: roughly 80% to 90% were identified. This is similar to the previous study (Martinek, Hilligos, and Lavicka, 1978) in which the RO376 display resulted in 90% completeness. For both the Army and the Navy operators, therefore, once a target has been detected, the probability of a correct identification is similarly high.

Table 9

Percentage Identification Completeness by Session and String Size

	2-sensor	3-sensor	4-sensor
Session I	72	82	78
Session II	88	87	92

The target activity variable is significant. As with the rights (detection) results, this outcome was expected for the identification rights. Of the targets detected in the low-target-activity condition, 90% were identified, whereas in the high-target-activity condition 81% were identified.

Of more importance is the significant interaction between sessions and target activity (Table 7). The means are given in Table 10. The significant interaction suggests that performance did not increase similarly for both activity conditions but that the high-activity condition resulted in a larger increase. The training objective of better performance for the high-activity condition was satisfied.

Table 10

Mean Number of Identification Rights by Session and Target Activity

	Low-target activity	High-target activity	Sum
Session I	3.5	4.8	8.3
Session II	4.3	6.6	10.9
Average	3.9	5.7	

Table 11 presents identification completeness (i.e., percentage of targets identified to targets detected). There are no significant differences between Session I and Session II. The t-test values (df = 19) were 1.409 for the low-target-activity condition, and 1.20 for the high-target-activity condition.

The string size by target activity interaction presented in Table 12 is significant at the .01 level. This table reveals that the number of identification rights is substantially lower for the 2-sensor string condition for both the low- and high-target-activity conditions. These results are very similar to those for detection rights.

Table 11

Percentage Identification Rights Completeness by Session and Target Activity

	Low target activity	High target activity
Session I	85	79
Session II	94	85

Table 12

Mean Number of Identification Rights by String Size and Target Activity

	2-sensor	3-sensor	4-sensor
Low-target activity	2.0	3.1	2.7
High-target activity	2.3	4.8	4.3
Average	2.1	4.0	3.5

The scenario variable was significant at the .01 level, which indicates that Scenario A (with an average of 4.4 rights) was more difficult than Scenario B (with an average of 5.3 rights). The difference in scenarios is probably due to a difference in target difficulty, as revealed in the high- and low-target-activity conditions shown in Table 13. This table suggests that the interaction (significant at the .01 level) is due to the noticeably lower performance in the high-target-activity condition (4.9 rights) of Scenario A. As with the detection outcome, a further analysis of these data is beyond the objectives of this research but could be useful for scenario development in future research.

The triple interaction of string size, scenario, and target activity is significant. The results are presented in Table 14. For each target activity level, note the lower number of correct identifications for targets involving 2-sensor strings, and the differences across scenarios for 2-sensor strings.

Table 13

Mean Number of Identification Rights by Scenario and Target Activity

	Scenario A	Scenario B	Sum
Low-target activity	3.8	4.0	7.8
High-target activity	4.9	6.5	11.4
Average	4.4	5.3	

Table 14

Mean Number of Identification Rights by String Size, Scenario, and Target Activity

	Low target activity		High target activity	
String size	Scenario A	Scenario B	Scenario A	Scenario B
2-sensor	1.1	.9	.7	1.7
3-sensor	1.4	1.8	2.3	2.6
4-sensor	1.3	1.4	2.1	2.3
Average	1.3	1.4	1.7	2.2

The interaction of sessions x string size x target activity was not significant, which indicates that the previous discussions of these variables need not be modified due to a triple order effect.

The remaining interactions are string size x scenario, and those involving groups. They have little bearing on the objectives of this study and are therefore not discussed.

Confidence Ratings. The analysis of variance results for the confidence variable is presented in Table 15.

Table 15

Analysis of Variance Table for Confidence Values

Source	df	SS	MS	F ratio	Sig. level
Between-subjects	19	6.61			
Groups	1	.90	.90	2.84	NS
Error (b)	18	5.71	.38		
Within-subjects	20	1.25			
Sessions	1	.004	.004	.062	NS
Scenarios	1	.08	.08	1.25	NS
Error (w)	18	1.17	.065		
Total	39	7.86			

No significant differences occurred. Either there is no difference in confidence or there are differences in confidence but the rating technique for measuring an operator's confidence was inadequate. The latter case is probably true, since the variation between-subjects (Table 15) is far greater than the variation within-subjects. This occurred because each operator tended to select and use only a particular confidence level, even though some target activation patterns were more difficult than others.

Measuring the confidence of operators could be useful to the field commander when he is weighing fragments of intelligence from several sources in a battle situation. Knowing how confident the operator is in his judgment could influence the importance that the commander will place on the information. This was the first time that these monitors had been asked to rate their confidence. The rating system perhaps could have been more useful if the operators had been given more extensive instruction and had been helped to develop adequate anchor points across the scale.

Reporting Time. The F-max test of the homogeneity of variance indicated that this basic assumption in use of the analysis of variance model was not satisfied. Therefore, a log transformation of the reporting time scores was performed. Table 16 presents the results of the analysis of variance, using the log transform of reporting time. Both the groups and sessions variables were significant at the .05 level. The results on groups has no impact on the objectives of the

study except for control purposes. However, the results on the sessions variable indicates that the training resulted in a time saving in the reporting of targets. An operator required 5.9 minutes to report a target before training and 5.0 minutes after training--a time saving of 15% for each target reported. Operationally this means that a target would be reported 1 minute earlier. In addition, during an overload situation when operators have more targets than they can report, an operator who has received special training will be able to report more targets.

Table 16

Analysis of Variance Table for Reporting Time[a]

Source	df	SS	MS	F ratio	P
Between-subjects	19	.4151			
Groups	1	.1780	.1780	13.59	.01
Error (b)	18	.2371	.0131		
Within-subjects	20	.2181			
Sessions	1	.0440	.0440	4.94	.05
Scenarios	1	.0127	.0127	1.43	NS
Error (w)	18	.1612	.0089		
Total	39	.6332			

[a]Log transform of reporting time used.

Additional time savings (4 minutes) could also be incurred by having the operators send out a target detection report immediately after target detection and then by a followup target identification report several minutes later. For target acquisition, these few minutes could be very valuable for processing the information and alerting gun crews.

Measurement and Computational Procedures

Use of the column-length formula provides two bits of information used for military intelligence purposes, target speed and target quantity (the number of targets in a column). Solution of this formula requires two target-pattern measurements which are taken directly from

the activation readout. These are TT_1 and T_M, which have been discussed previously. Analyses are reported below for TT_1, T_M, target speed, and target quantity. The school-solution criteria of correctness are discussed in the Method section.

TT_1. The analysis of variance for TT_1 is presented in Table 17. The sessions variable is significant at the .01 level, which indicates that the training was effective. The posttest results of 6.45 average correct measurements represents a 63% improvement over pretest results of 3.95. The groups and scenarios variables are nonsignificant.

Table 17

Analysis of Variance Table for TT_1 Values

Source	df	SS	MS	F ratio	Sig. level
Between-subjects	19	109.40			
Groups	1	3.60	3.60	.613	NS
Error (b)	18	105.80	5.87		
Within-subjects	20	184.7			
Sessions	1	62.5	62.50	9.27	.01
Scenarios	1	.9	.90	.134	NS
Error (w)	18	121.3	6.74		
Total	39	294.1			

T_M. The analysis of variance for T_M values is presented in Table 18. The sessions variable is statistically significant at the .01 level which indicates that the training was effective. Posttest results of 6.8 average correct measurements represent a 58% improvement over pretest results of 4.3. The groups and scenarios are nonsignificant.

The results of TT_1 and T_M are almost identical. This was not unexpected because both involve measurements taken directly from the X-T display and, therefore, demonstrate the effectiveness of the training given for the endpoints (Lesson 3) and the use of the UGS ruler job aid.

Table 18

Analysis of Variance Table for T_M Values

Source	df	SS	MS	F ratio	Sig. level
Between-subjects	19	88.90			
Groups	1	0	0	0	NS
Error (b)	18	88.90	4.94		
Within-subjects	20	217.00			
Sessions	1	62.50	62.50	8.35	.01
Scenarios	1	19.60	19.60	2.62	NS
Error (w)	18	134.90	7.49		
Total	39	305.90			

Target Speed. Table 19 presents the results of the analysis of variance for the target speed variable. Again, there is a significant (.01 level) increase of posttest results over pretest results.

The average operator performance on the pretest is 3.9 correct and that for the posttest is 6.4 correct, representing a 64% increase in accuracy of reporting the speed of the targets. However, most of this increase is attributable to the increased accuracy of obtaining T_M. The groups and scenario variables are nonsignificant.

Quantity. Table 20 presents the results of the analysis of variance for quantity. Again the session variable is significant at the .01 level. The average operator performance on the pretest was 3.95 correct and that for the posttest was 6.45 correct, a performance increase of 63%. The difference between operator performance on the two scenarios (4.5 correct on Scenario A and 5.9 correct on Scenario B) was significant at the .05 level.

Within-Course Performance

In developing instructional systems, it is standard procedure to collect data that can assist the course developer to effectively revis his materials. In addition to pretest and posttest performance, opera tor performance on individual lessons can provide effective guidelines for revisions that can result in improved posttraining performance on

Table 19

Analysis of Variance Table for Target Speed Values

Source	df	SS	MS	F ratio	Sig. level
Between-subjects	19	82.10			
Groups	1	.40	.40	.09	NS
Error (b)	18	82.70	4.54		
Within-subjects	20	157.00			
Sessions	1	62.50	62.50	13.33	.01
Scenarios	1	10.00	10.00	2.13	NS
Error (w)	18	84.50	4.69		
Total	39	239.10			

Table 20

Analysis of Variance Table for Quantity Values

Source	df	SS	MS	F ratio	Sig. level
Between-subjects	19				
Groups	1	2.50	2.50	.34	NS
Error (b)	18	130.90	7.27		
Within-subjects	20	151.00			
Sessions	1	62.50	62.50	16.32	.01
Scenarios	1	19.60	19.60	5.12	.05
Error (w)	18	68.90	3.83		
Total	39	284.40			

subsequent administrations. Although a formal evaluation using operator performance data was not within the scope of this effort, the data on individual lesson performance are provided, to present a complete picture of the effect of the training and to allow for improvements of the course materials in subsequent efforts.

Table 21 presents the scores on the criterion exercise for each lesson for each operator. Each operator's first attempt is given as well as scores on subsequent recycles. It should be recalled that an operator had to get 100% correct on each criterion exercise before being allowed to proceed to the next lesson. It is apparent from Table 21 that Lessons 3 and 5 presented the greatest amount of difficulty for the operator. Over 50% of the operators had to recycle on these two lessons, which indicates that the training materials should be revised.

As with most individualized, self-paced training systems, operators varied widely in the amount of time they required. One operator had completed half of the lessons by 10:15 a.m., and over 50% of the operators finished Lesson 4 by the end of the morning. One operator completed all eight lessons by 2:30 p.m., (1-1/2 hours early), 75% of the operators were finished by 3:00 p.m., and only one operator took the full time allotted.

Student Questionnaire Results

The questionnaire was administered to obtain a measure of student acceptance of the individualized, self-paced training system and to provide further data that could help guide revisions of the training system and materials. Summaries of the questions and answers are presented below.

Overall Assessment of the Training System. Only 2 of the 20 operators indicated that they had ever received like training, and this had occurred in high school. When asked for their overall impression of the training compared to the conventional classroom method, 13 indicated it was "definitely better," and 7 indicated it was "somewhat better." None indicated it was "worse" or "no difference." Nineteen operators indicated they would like to receive more training using this technique. Overall, the subjects were quite favorably disposed toward the training given.

Best and Worst Things About the Training System. The following answers were given to the question "What did you like the most about this system of training?"

- Tolerance allowed in answers;
- Open-minded instructors;

Table 21

Data Management Sheet of Criterion Exercise Recycling

Lesson	1. UGS ruler		2. 2-sen strg		3. End-points		4. C-L quant		5. Non-strstp		6. EMID		7. MAGID		8. DIRID	
	score	recycle	score	recycle	score	recycle	score	recycle	score	recycle	score	recycle	score	recycle	score	recycle
1	9	10	10	-	6	10	5	5,6	10	-	10	-	8	9,9,10	10	-
2	10	-	10	-	7	8,10	6	-	10	-	8	10	9	10	10	-
3	10	-	10	-	8	10	5	6	10	-	10	-	9	10	10	-
4	10	-	9	10	7	10	4	4,5,6	6	10	10	-	6	7,9,9,10	9	10
5	9	10	8	10	7	9,10	6	-	9	10	7	10	9	10	10	-
6	10	-	10	-	8	10	6	-	7	8,9,10	9	10	10	-	8	10
7	10	-	10	-	10	-	6	-	10	-	9	10	10	-	10	-
8	9	10	8	10	10	-	6	-	9	9,10	10	-	9	10	10	-
9	10	-	10	-	5	9,10	6	-	9	10	7	10	10	-	10	-
10	10	-	8	10	4	9,10	6	-	8	9	10	-	7	10	5	8,10
11	7	10	10	-	4	8,10	6	-	7	8,10	10	-	9	10	10	-
12	10	-	10	-	9	10	6	-	10	-	10	-	10	-	10	-
13	10	-	9	10	6	10	6	-	9	10	8	10	9	10	10	-
14	9	10	10	-	7	7,10	6	-	10	-	8	10	9	10	10	-
15	9	10	10	-	10	-	6	-	9	10	9	10	10	-	10	-
16	10	-	9	10	9	10	6	-	9	9,9,10	8	10	7	10	9	10
17	10	-	8	10	9	9,9,10	4	6	8	10	9	10	8	10	10	-
18	10	-	9	10	9	8,9,10	6	-	9	9,10	9	10	9	10	10	-
19	10	-	10	-	10	-	6	-	10	-	10	-	10	-	10	-
20	10	-	8	10	9	10	6	-	9	10	9	10	9	10	10	-

- Worked at own pace;
- Made learning a little more interesting;
- Lessons were easier to understand;
- Question sheets were not too long;
- Checking own answers;
- Relaxing atmosphere, informality, not as boring;
- Refreshed memory;
- Lesson, then application and help from instructors;
- Had examples on paper to help you, whereas in the classroom you don't;
- Absence of boring lectures and excess verbiage; and
- Learn a little more because you get tested right then.

The following answers were given to the question "What did you dislike most about this system of training?"

- Nothing;
- Did not have time to get important items into personal notes for reference;
- Not enough breaks;
- Too much tolerance allowed on some answers;
- Some of material was incorrect;
- Tired at the end of the last couple of lessons, and you don't always grasp the full understanding;
- Some of the material was not presented very clearly--too easy to misunderstand questions;
- Too much time waiting in line between stations to get your materials;
- Not enough discussion;
- Too long, too many tests over too short a period;

- Went into too much detail on instructions at times; and

- The feeling of hurrying to get done.

Suggestions for Improvement of the Training System. The following answers were given to the question "If you could make some changes in how this training system operates what would you change?"

- Use better equipment (note: two machines in the testing phase caused difficulty);

- Give 10-minute break every hour;

- Increase the probability that the student actually uses the material, perhaps with longer or more complicated test;

- Leave it the way it is;

- Have more instructors available (to reduce waiting in line);

- Give out the lesson and practical exercise at the same time;

- Include lecture and group question and answer period, also hands-on time for new students;

- Make some of the more difficult questions more simple; and

- Do not know.

Student Assessment of Specific Lessons. In answer to "Were there any lessons that you felt you did not need?" all 20 operators answered "No." In answer to "Were there other areas of content that you feel should have been discussed or reviewed?" 16 operators answered "No." Topics suggested by the remaining four operators were (1) physical-security sensors and (2) sensor-implantation information.

The ninth question requested the operators to rate each component of the lessons in terms of clarity of presentation and difficulty to answer. Table 22 shows the results of the operator ratings. The weighted sums were computed to make some elementary within-lesson comparisons of lesson content, practical exercise questions (PEQ) and criterion exercise questions (CEQ) as well as across-lesson comparisons. The weighted sums were also totaled for each lesson in order to assess the overall effect of the lesson.

Note that the lower the weighted sum, the greater the clarity as perceived by the operators. However, the lower the weighted sum, the greater the difficulty as perceived by the operators. Therefore, a "1" on the rating scale means very clear or very difficult. The use of these data, along with the within-course performance data and the

Table 22

Operator Ratings of Clarity and Difficulty on Lesson Materials

		Clarity						Difficulty					
		Very clear				Not clear	Weighted sums	Very difficult				Not difficult	Weighted sums
Lessons		1	2	3	4	5		1	2	3	4	5	
1. UGS ruler		15	4			1	28						
	PEQ	13	4	2		1	32	1	1	3	2	13	85
	CEQ	13	3	2		1	30		1	4	2	12	82
							90						167
2. Two-sensor strings & formula review		10	7	2		1	35						
	PEQ	10	8		1	1	35		2	8	6	4	72
	CEQ	8	7	2	1	2	42		4	3	8	4	69
							112						141
3. End-points		11	5	2	1	1	36						
	PEQ	9	8	3			34		5	3	7	5	72
	CEQ	8	5	5	1	1	42		6	6	4	2	58
							112						130
4. Column length quantity		10	5	2	2	1	39						
	PEQ	10	5	2	2	1	39	1	3	3	5	8	76
	CEQ	12	4	1	2	1	36	1	3	2	3	10	75
							114						151
5. Non-stairstep activation patterns		10	6	3		1	36						
	PEQ	11	6	1	1	1	35	3		6	5	5	66
	CEQ	10	5	3		1	34	3	1	5	4	5	61
							105						127
6. EMID		12	4	3	1		33						
	PEQ	10	6	2	2		36	1	3	2	6	7	72
	CEQ	7	4	4	4		43		3	5	7	4	69
							112						141
7. MAGID		7	9	2	1	1	40						
	PEQ	9	7	3		1	37	1	4	2	7	5	68
	CEQ	11	6	2		1	34	2	1	4	6	6	70
							111						138
8. DIRID		11	3	3	2	1	39						
	PEQ	10	6	2	1	1	37	1	3	2	3	8	65
	CEQ	10	4	4		1	35	1	2	3	2	9	65
							111						130

pretest and posttest results, would allow for a more effective revision of the materials.

The following summarizes the answers to "List any suggestions you might have for improving a specific lesson or component."

- Have this kind of work available more often;
- Pick up all materials in one trip;
- Make note-taking possible;
- Use better equipment (machines in training course);
- Give 10-minute information to all of them;
- Reword some of the lesson sheets to increase clarity;
- Add a little more information to all of them;
- Break all sessions down to about 3 or 4 hours at a time; and
- Read lessons aloud and explain them.

Job Aid Performance Measures

Six target variables were statistically analyzed to determine the effectiveness of the nomograph job aid in combination with the UGS ruler: TT_1, T_M, target type, column length, target quantity, and reporting time. Table 23 presents the average operator performance on the pretest and posttest for each of the variables. As shown in the table, all of the variables tested are statistically significant. It is concluded that use of the UGS ruler and nomograph substantially improved operator performance.

The UGS ruler, which is used to measure TT_1 and T_M values, resulted in 63% and 121% improvement, respectively. Note that the operators had previously been trained and given UGS rulers (separate from the nomograph) to use during the self-paced training. The effect of this on the above-mentioned comparisons is difficult to judge. However, the improvement scores are probably lower than they would have been had the operators not been exposed to the first experiment. Because the operators had been exposed to the idea of accurately measuring TT_1 and T_M to within .1 minute by using the UGS ruler, they were inclined to achieve this same accuracy. Prior to the training experiment the operators had been taught to round off their time estimations to the nearest half-minute. However, over half of them were estimating their time values to the .1 minute during the above pretest. If they had retained the half-minute criteria, their TT_1 and T_M correctness values

Table 23

Effect of UGS Ruler and Nomograph Upon Target Variables

Dependent variables and job aid involved	Average number		Percentage improvement	Difference score	t value	df	Sig. level
	Pretest	Posttest					
UGS Ruler[a]							
1. Total time first sensor activated (TT_1)	5.4	8.8	63%	3.4	6.48	19	.01
2. Mean time (T_M)	3.3	7.3	121%	4.0	6.69	19	.01
Nomograph/UGS Ruler							
3. Speed	3.6	7.1	97%	3.5	5.83	19	.01
4. Target type (identification)	9.1	9.7	7%	.6	2.61	19	.01
5. Length of column	4.2	7.0	67%	2.8	4.47	19	.01
6. Quantity	4.9	6.9	41%	2.0	3.01	19	.01
7. Reporting time per target	3.9 min.	3.3 min.	15%	.6 min.	2.43	19	.05

[a]Use of the UGS ruler in measuring 1 and 2 above would affect the results of variables 3 through 7.

(and related computations) during the pretest would have been poorer than they actually were. Thus, exposure to the UGS ruler and the concept of accurate measurement probably reduced the pre- and posttest differences (which were substantial).

In summary, the following percentage improvements occurred: target speed, 97%; target type, 7%; column length, 67%; and quantity, 41%. The relatively low percentage improvement shown for target type should not be misunderstood. Target speed is the major determiner of target type, and the percentage improvement for target speed is substantial. The criterion of 150 meters per minute was used in this study, i.e., targets traveling slower than this speed were called personnel and targets traveling equally as fast or faster were called vehicles. The number of times in which increased information accuracy (as provided by the nomograph) will make the difference between calling a particular target personnel or vehicle will differ depending upon how close the speed is to 150 meters per minute. The number of times in which it occurred in this study was left to chance, as it occurred in the material obtained from the field.

A 15% improvement over pretest time occurred in time taken to report on each target. The percentage improvement is lower than had been expected. However, analysis of what the job aids do for an operator indicates that reporting time might not be greatly affected. The job aid certainly should reduce the time required for performing calculations. However, measurement of $T_M \times TT_1$ with the ruler should require more time than just estimating those values.

The training and testing of the utility of the nomograph/UGS ruler job aid combination occurred after the data collection on the individualized training study. Therefore, the operators had received a lot of practice in making the necessary measurements and computing the speed and quantity of targets. However, it was not known whether or not the operators had reached their "normal" level of competence. If they had not, then the additional practice received during Session I could increase their scores in Session II but could appear to be due to the use of the nomograph/UGS ruler.

If learning or practice effects occurred in Session I (and to some extent Session II), this increase should be evident in a comparison of performance on the problems in the first half of each session with that on the problems in the last half of the sessions. This assumes that the problems in the first half are equal in difficulty to those in the second half. Table 24 presents these data for the speed and quantity computations. Because the second half of the problems in each session actually resulted in lower operator performance scores, it is concluded that no learning/practice effects occurred, but that the differences between Session I and Session II were due to the use of the nomograph/UGS ruler job aid.

Table 24

Number Right of First Half Versus Second Half of Test on Speed and Quantity Estimations

	Session I		Session II		Total	
	1st Half	2d Half	1st Half	2d Half	1st Half	2d Half
Speed	42	34	78	64	120	98
Quantity	45	43	72	68	117	111

Practice effects apparently occurred on the time variable. Table 25 shows a marked difference between the first and second halves of both Sessions I and II, with the biggest difference occurring in Session I. A plot of the individual items (Figure 3) shows this effect more clearly. From items 1 to 5 in Session I there is a decrease in time, after which it tends to remain constant. The average time for the first five items was significantly higher (.05 level; $t = 2.34$, $df = 8$) than the average for the first five items. In Session II there is an initial "warmup" or perhaps practice on the first or first four items offered, after which time/item remains fairly constant. Therefore, it is concluded that most, if not all, of the session differences found in the time variable are attributable to practice (learning, warmup, etc.).

Table 25

Average Time for First Half of Test Versus Second Half of Test

	Session I		Session II		Total	
	1st Half	2d Half	1st Half	2d Half	1st Half	2d Half
Average time	22.1	16.9	18.5	15.5	40.6	32.4

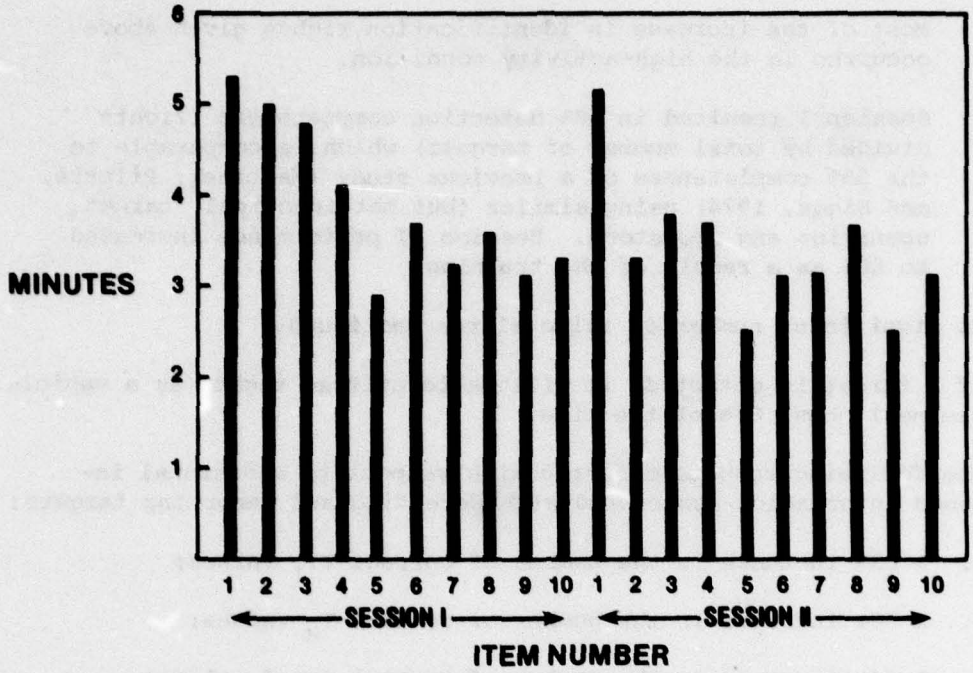

Figure 3. Reporting time by item.

CONCLUSIONS AND RECOMMENDATIONS

Conclusions

1. The individualized training program developed from an analysis of operator errors improved the performance of UGS operators, as follows:

   a. An 18% increase in the number of detection rights (which is one target per operator per hour on the average).

   b. About half of the above increase occurred in the 2-sensor string condition.

   c. The largest increase in detection rights occurred in the high-target-activity condition.

   d. A 31% increase in the number of identification rights (which is, on the average, 2-1/2 targets per operator every 2 hours). This outcome includes the increase attributable to the increase which occurred for detection rights.

e. Most of the increase in identification rights given above occurred in the high-activity condition.

f. Session I resulted in 58% detection completeness (rights divided by total number of targets) which is comparable to the 55% completeness of a previous study (Martinek, Pilette, and Biggs, 1974) using similar (but not identical) target scenarios and operators. Session II performance increased to 68% as a result of the training.

2. No significant number of false alarms was found.

3. If a target is detected, it will be identified right (as a vehicle or personnel) about 85% of the time.

4. The following results occurred with respect to additional intelligence information associated with detecting and reporting targets:

a. A 63% increase in the number of correct TT_1 values;

b. A 58% increase in the number of correct T_M values;

c. A 64% increase in the number of correct speed values;

d. A 63% increase in the number of correct quantity values; and

e. A 15% reduction in the time for target reporting.

5. Answers to a questionnaire given to the operators after the training indicated a strong favorable reaction to the self-paced, individualized training approach. Thirteen operators indicated that the training approach was "definitely better" than the conventional military training they had received. The remaining seven operators indicated it was "somewhat better." None of the operators indicated it was "worse" or that there was "no difference" between the two. Operator reactions were obtained on all aspects of the training as reported in the Results section. Although acceptance of the UGS ruler was not specifically treated in the questionnaire, the researchers noted that such acceptance was high, judging from the amount of use it received and the difficulty encountered in getting the rulers back from the operators.

6. In the second study, the nomograph/UGS ruler job aid combination was favorably received and improved operator performance on the following variables.

a. 63% increase in correct TT_1 values;

b. 121% increase in correct T_M values;

c. 97% increase in correct speed values;

d. 7% increase in target identifications;

e. 67% increase in correct length of column values;

f. 41% increase in correct quantity values; and

g. 15% reduction in reporting time.

7. Use of 3- and 4-sensor strings produced about the same operator completeness (80% and 69%) and better completeness than use of 2-sensor strings (48%). However, more vehicle targets (presumably easier) occurred in conjunction with the 3- and 4-sensor strings than with the 2-sensor strings.

8. Considering both sessions, a higher completeness is found during periods of low target activity (76%) than high target activity (65%).

9. After training, operator performance on the 3- and 4-sensor strings was 77% completeness with virtually no false alarms.

10. Scenario differences were found, despite the attempt to eliminate them as a source of variation.

Recommendations

1. The improvements in operator performance that occurred as a result of the training lead to the recommendation that the lesson materials (or portions), together with the individualized training approach, be refined and implemented as follows:

a. Provide review and on-the-job training in the field, and

b. Be integrated into the required training for UGS operators at Fort Huachuca, Ariz.

2. It is further recommended that the nomograph and UGS ruler be

a. Taught during required training for UGS operators at Fort Huachuca, Ariz., and

b. Included as standard issue with the RO376, the BASS III, and any newly developed recorders.

3. An additional study, controlling for target differences, should be done comparing the 2-, 3-, and 4-sensor string conditions. If operator performance is the only criterion, this study indicates that

three sensors produce as much target information as four. Conceivably, two sensors may be as good as three or four.

4. A report of the detection of a target should be sent forward using two sensors (or more in cases where two are not sufficient) with a followup report giving speed, number of objects, and type of target. This will provide an alert function at the earliest possible time.

5. Operator performance is at an acceptable level.

6. In future tests and research concerning UGS, scenario differences probably will occur and should be controlled experimentally and/or statistically.

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Appendix A

LESSON--TWO-SENSOR STRINGS AND FORMULA REVIEW

Objective

To enhance awareness in detecting 2-sensor strings and to provide recall or basic training in computing the column-length formula.

Purpose

Detecting target patterns from 2-sensor strings are important because they can frequently provide as much information as strings with more sensors.

Concept

Two-sensor strings may be deployed for the following reasons:

1. Along roadways when there is a shortage of sensors,

2. On mountain or hilltop areas to detect movement, and

3. Where only two sensors are functioning out of a larger string because of failure or damage.

When 2-sensor strings are deployed together in the same sensor field with 3, 4, and 5-sensor strings, it is easy to miss their activation patterns. Two-sensor string patterns can easily be overlooked because the larger string patterns are much more obvious. The 2-sensor string patterns may yield equally relevant information concerning enemy movements, but to detect them sometimes requires more careful observation.

In order to maximize the chances of detecting 2-sensor strings the following guidelines are helpful:

1. Check the Sensor Data Record and Sketch Maps carefully for the location and pen numbers of 2-sensor strings.

2. When activations occur on both pens in the familiar stairstep pattern, the chances are good it is a target.

3. When activations occur on both pens, but not in the familiar stairstep pattern, they may or may not represent a target. Check other sensors in the area to determine if the activations could be the result of noise activity such as artillery or aircraft.

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The Column-Length Formula requires a minimum of 2-sensors; therefore, it can be used on the 2-sensor strings.

To review, the Column-Length Formula is

$$L_C = \frac{D}{T_M} (TT_1) - CDR,$$

where

L_C = length of the target column (in meters),

D = distance between the sensors (in meters,

T_M = time difference (in minutes) between the mid-point of the first sensor activation pattern and the mid-point of the second sensor activation pattern,

TT_1 = total time (in minutes) of the first sensor activation pattern, and

CDR = Combined Detection Range (in meters). The <u>sum</u> of the detection range of the first sensor and the detection range of the second sensor. CDR is used instead of DR to eliminate confusion between the detection range (DR) of one sensor and the detection range of <u>two</u> sensors when they are added together (CDR).

The following values were measured from the 2-sensor string in Figure 1 (pens 3,4). Check them for correctness.

T_M = 2 min.

TT_1 = 3 min.

The Formula is solved using the following assumptions:

D = 500 meters (m)

CDR = 600 meters (m)

$$L_c = \frac{D}{T_m} (TT_1) - CDR$$

$$= \frac{500m}{2 \text{ min.}} (3 \text{ min.}) - 600m$$

$$= 250 \frac{m}{\text{min.}} (3 \text{ min.}) - 600m$$

$$= 750m - 600m$$

$$L_c = 150m$$

Since the speed of the target is 250 m/min, it is considered vehicular. To determine the number (quantity) of targets in the column the L_c is divided by 50m as shown.

$$\text{Quantity (Q)} = \frac{L_c}{50m} = \frac{150m}{50m} = 3 \text{ vehicles.}$$

Of course, if the speed is less than 150 m/min the L_c would be divided by 5m.

WHEN YOU ARE FINISHED WITH THIS LESSON TAKE IT TO THE TRAINING MONITOR (STATION 2) AND PICK UP YOUR PRACTICAL EXERCISE QUESTION SHEET.

Appendix B

SUBJECT INSTRUCTIONS

A. Test Procedure Training

MONITOR: Read the following instructions:

As you already know, you have been selected to participate in a research effort to study UGS performance under various conditions as they might exist in the field. We have been asked by the Department of the Army to administer this exercise to you, collect performance data, analyze the results, and submit a report. I want to make it clear at the outset that our objective is not to isolate each of you and attach a proficiency score to each of you. Our objective is to determine the total capability of the UGS information potential as it combines both the person (you) and the machine output (the UGS record). However, your performance will be scored and given to your platoon leader so that he will have some idea about how good you are compared to the rest of the group in the readout of the RO376 event recorder.

Since other groups of UGS operators have taken or will be taking this exercise, I will be looking frequently at my notes to be sure everyone gets the same information. You will have opportunities throughout this entire program to ask questions.

To summarize the entire exercise, you will be given UGS sensor records (X-T plots) to interpret. These plots, for the most part, are target activations that have been collected under various field exercises primarily in the Fort Hood area. Involved in these exercises were varying numbers of tanks, Armored Personnel Carriers (APC's), and personnel. These tests also contain noise activations which are typical of wartime operation such as: fixed-wing and helicopter activity, malfunctioning and unreliable sensors, radio interference, weather/wind activity, and artillery shell bursts. All we ask is that you interpret the X-T plots to the best of your ability and try to make sense out of what sometimes might appear to you to be rather difficult. Let me stress that we have tried to make these records as realistic as we could.

You should interpret these X-T plots as though you are under battlefield conditions. However, in wartime it will be a lot worse. You won't slow down then, because your life may depend on how well you do your job. However, at the risk of sounding melodramatic, keep in mind that you should try, because there is a great need for the Army to find out how typical UGS specialists will be able to function under battle conditions that we selected.

You are important because you, as a group, represent the hundreds of specialists that have graduated and will graduate from the UGS school

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for a long time to come. Army deployment plans for UGS equipment and personnel will be partly influenced based upon what you can do.

MONITOR: Pass out the packets and read the following instructions:

The next sheet should be a TARGET LOG. On this sheet you will record most of the target information you would regularly record on a SENSOR ACTIVATION SPOT REPORT plus additional information. Note the first column of the target log. This is the target pattern number. For activation patterns on the chart paper that you think are targets, circle the target on the chart paper and number it. Record the number in the first column. For each target that you detect, always number it and record it on your target log. If you detect a target, but later feel it is not a target, do not erase what you have written, but simply write "No Target" and start recording the next target on the space below. Number all your targets consecutively in sequence.

In column 2 record the clock time that you made a target detection and round it off to the nearest minute. You may use your wrist watch, but be sure it is synchronized with the wall clock.

In column 3 record the pen numbers of the sensor string.

In column 4 record how confident you are that what you think is a target really is a target. Use the terms for your confidence that are shown at the bottom of the target log sheet: positive, high, 50/50, and low. Tell us how confident you are that the activation pattern you are looking at really is a target, assuming that you will be sending this information to your Company Commander during a battle situation. He knows you are doing your best but he wants to know how confident you are in the information you are sending to him. If you are not confident in your information then he will place a higher weight on the information being supplied to him by other intelligence sources such as realtime IR reconnaissance, radar or electronic intelligence. The confidence estimate should relate only to your detection of a target and not necessarily to any of the following information.

In column 5 record the direction of movement of the target. Use the terms NW, NE, SW, and SE.

In column 6 compute the speed of the target using the formula

Speed (S) = D/T_M

where D = distance between sensors, and

T_M = time of activations from center of the first sensor activation to the center of the second sensor pattern. Show your calculations for speed in the space provided. Round off your speed to the nearest meters/minutes.

In column 7 record the target type, whether personnel or vehicular. If the speed is less than 150 meters/minute call the target "personnel" and write P. If the target speed is greater than 150 meters/minute call the target "vehicles" and write V.

In column 8 compute the length of the target column using the formula

$$L = S\ (TT_1) - D_R$$

where S = speed calculated and recorded in column 6,

TT_1 = total time the first sensor was activated, and

D_R = detection range which is the detection radius of the first sensor plus the detection radius of the second sensor added together. In this test the detection radius of all sensors in a string is the same.

Substitute the values in the formula in the spaces provided and show your work. Do your actual multiplication on scratch paper. Round off your numbers where appropriate.

In column 9 record the quantity or number of units in the target. If the target is personnel divide the length of the column by 5 meters to determine the number of personnel. If the target is vehicles divide the length of the column by 50 meters to determine the number of vehicles.

In column 10 record the clock time in which you are finished with the target and are ready to send the information to your Company Commander.

The sequence of the information required on the target log was planned, and we want you to try to use this sequence. Does anyone have any reservations about this sequence?

MONITOR: Discuss the implant sketch (Field I) and read the following:

Remove your target log and place it aside. The next sheet should be an IMPLANT SKETCH, which is marked on the upper right-hand side--Pretest Part I. As you know, implant sketches show the location of the sensor strings.

During the next couple of days, you will be using implant sketches very similar to this one. The implant sketches will show the location of the sensors along the roads and trails. Give the pen number for each sensor, the string number, and the distance between the sensors.

As you can see, the spatial relationships between the sensors are not drawn to scale. This is the case with all the implant sketches you will be given during this entire exercise. The purpose of this implant sketch is merely to present you with the information that you will need. There will also be times in which you may disagree as to the placement of the sensor strings in the various deployment patterns. Although certain string deployments may differ from what you feel or have been taught is correct, accept the deployments presented, keeping in mind that in operational situations there are many factors involved in deploying sensors. The sensor-string deployments are the ones used in the Fort Hood tests and are adequate for purposes of this exercise.

The implant sketches will also provide you with information as to whether the string contains a MAGID, EMID, or DIRID sensor. In this implant sketch (Pretest--Field I) there is one MAGID.

Place the implant sketch aside. The next sheet should be a SENSOR PROGRAM RECORD. This sheet provides the string number and field designation, sensor type, and detection ranges of the various sensors. This sheet contains four sections to provide this information for four different sensor fields. On this sheet three sensor fields are shown: I, II, and III. Right now we will be concerned with only the first sensor field labeled Roman Numeral I. The sensor record or read-out sheets you probably used to work with contain a great deal more information including geographical coordinates, sensor ID, sensor frequency, mode, and inhibit times. The ones we will work with are simplified for purposes of this exercise.

Notice that for detection radius, a value is given for vehicles and for personnel. Detection radius varies greatly for vehicles and personnel depending upon the sensor type, soil type, and gain setting.

MONITOR: Administer Pretest Part I and read the following:

Place your target log, implant sketch, and sensor record in a convenient place near your event processor which is already loaded with our X-T chart paper. Place your packet aside. We will work through a 30-minute practical exercise, in which we will use the materials we have just discussed. Fill out your target log and use your implant sketch and sensor record. As you detect patterns that you think are targets, circle the pattern on the chart paper with your pencil and place the number of the target next to the circle. Then fill out your target log by first recording this number in column 1. Are you ready? Start monitoring.

MONITOR: Turn on drive mechanisms and check each subject to be sure all are working with the proper materials. When the first group of noise activations has completely appeared, find out if anyone called them targets. When the first, second, and third targets have each

appeared (in different time frames), find out who did not detect them as targets, and assist these people. For the first target, work out the calculations on the blackboard if necessary. Find out how this class is performing and give assistance individually or for the entire class as required. Emphasize aspects of the procedure that are not being performed. Check each man to be sure he is properly filling in all the information blanks on the target log.

At the end of the 30-minute period, turn off the event processors no more than 1/2-inch above the line separating the 30-minute periods and review procedures where appropriate.

MONITOR: Read the following:

During the practical exercises you will be given today, you will be monitoring various 30-minute chart preparations. After each 30-minute period you will be given a new implant sketch. We will begin the next 30-minute period shortly. Get your packets and take out the implant sketch marked Pretest--Part II in the upper right-hand corner. Do you have any questions concerning this one? Remember, you are numbering your targets consecutively (in sequence) so if you need additional target logs, let us know and we will supply them. Be sure you are working with the appropriate Sensor Record. For the next 30-minute segment you will be working with the Sensor Record, labeled Pretest II. Are there any questions before we begin the next 30-minute segment? All right, we will now start.

MONITOR: Conduct Pretest--Part II

Conduct in a similar manner as Part I except with somewhat less involvement of the monitors during the test. Check what procedural problems are still occurring. At the end of the 30 minutes, turn off the equipment. Address the entire class on procedural problems and reiterate where necessary.

B. Pretest and Posttest Training

MONITOR: Read the following:

You will now be given four 30-minute segments. You won't be stopped after each one, but you will proceed through all four segments as though you were working a 2-hour shift in the field. Take the material out of your packets. The first two sheets will be the Sensor Record Sheet and Implant Sketch for your first 30-minute period, and as you can see, they are the same as those you have used previously.

I would like to remind you that the wall clock is right there (Monitor: point to it) to get the times required on the target log.

If you are going to use your wristwatch, set it with the wall clock now. We will not be assisting you in any way to aid you in your target analysis. We will, however, be assisting you to make sure you are looking at the right sensor record and implant sketch throughout the exercise. If you have any questions with regard to whether or not you are using the proper sensor record or implant sketch, please do not hesitate to ask. Be sure to circle the activation patterns that you think are targets. Number these patterns consecutively and record in the first column of the target log. Are you ready? Begin.

MONITOR: Turn the equipment on. Check to see that all the equipment is running satisfactorily. Every 30 minutes the monitor will make sure that each subject is using the proper Implant Sketch and Sensor Record.

C. Individualized Training Administration

MONITOR: Read the following instructions:

Yesterday you worked on a practical exercise that required you to read-out an X-T plot. We haven't scored it yet, but from past experience with UGS operators such as yourself, we can say that all of you made errors. Today's training session will be directed toward errors previously made by other UGS operators. We assume that you also made similar errors. We believe this training plus the practice you received will increase your effectiveness as an UGS operator. It also keeps you out of PT and clean-up details.

This type of training has been used successfully in other educational systems and has been approved by training specialists. How well it works out here is one of the questions we are trying to answer. You will be asked to assess it, afterwards, in a questionnaire to get the UGS operator's point of view.

For most of you this training will be quite different from any training you have received in the past. The training system has been designed to allow you to proceed at your own pace, test your own knowledge after short segments of instruction, obtain immediate feedback on your mastery of the concepts, and receive expert assistance when you need it and want it. Those who are familiar with the concepts can proceed through the lessons at a fast pace, while those who need assistance can receive it when they need it.

In this self-paced training system the content is organized into distinct lessons, each covering a short segment of instruction. Each lesson contains a Lesson Sheet, a Practical Exercise Question Sheet, a Practical Exercise Answer Sheet, and a Criterion Exercise Question Sheet.

1. The Lesson Sheet is divided into three sections: Objective, Purpose, and Concept. The Objective section states what you should be able to do at the end of the lesson; the Purpose section discusses the importance of the lesson, and the Concept section contains the instructional materials with examples.

2. The Practical Exercise Question Sheet contains questions on the material discussed on the Lesson Sheets. These questions are intended to allow you to test your mastery of the concepts in the lesson.

3. The Practical Exercise Answer Sheet provides you with the correct answers to the questions and will allow you to check your own knowledge.

4. The Criterion Exercise Sheet contains questions relating to information on the Lesson Sheet. These questions test the same thing as the practical exercise questions and are the final check for mastery before going on to the next lesson.

For this exercise there are two monitors and one subject matter expert. They will assist you and monitor your progress through the system.

1. One monitor will be located at Station 1 and will control handout of the Lesson Sheet and he will score your CRITERION EXERCISES.

2. The second monitor will be located at Station 2 and will control all activities having to do with the PRACTICAL EXERCISES.

3. The subject matter expert will be located at Station 3 and will provide content assistance whenever it is needed.

There are five basic steps to be completed for each lesson: Read the Lesson Sheet, work the Practical Exercise Questions (PEQ's), check your PEQ's, answer the Criterion Exercise Questions (CEQ's), and have the Test Monitor check the CEQ's.

The specific steps for each lesson are as follows:

1. Get the Lesson Sheet from Station 1, return to your desk, and study.

2. Take the Lesson Sheet to Station 2 and give it to the Test Monitor.

a. Pick up the Practical Exercise Questions (PEQ's).

b. Return to desk and answer the PEQ's--answer all questions on the sheet.

3. Take completed PEQ sheet back to Station 2.

a. Show the Test Monitor that you have answered the questions.

b. Pick up PEQ Answer Sheet and Lesson Sheet.

c. Return to desk, check your answers, and resolve all incorrect responses. Do not erase or scratch out any of your original answers. We need to know your first responses so that we can improve the materials. If you need assistance, go to Station 3.

4. When you feel you understand all the material, take the Lesson Sheet, the PEQ's, and PEQ Answer Sheet back to Station 2.

5. Take completed CEQ's to Station 1 (Note: Station 1 is where you picked up the Lesson Sheet at the very beginning); the Test Monitor will check your answers.

a. If you got them all correct, pick up the next Lesson Sheet from the same Test Monitor and complete it as you did this one.

b. If you missed any questions, return to Station 2, and get all your materials for the lesson. Return to your desk and re-answer the questions you missed. Do not erase your original answer. We need that information in order to improve the materials. Write the number of the question you missed on the back of the CEQ Sheet and put your second answer there. Take your CEQ's back to Station 1 to be checked. If you missed them again, you will be required to go to Station 3 for assistance. (Take all your materials with you.) If you got them correct, you may proceed with the next lesson.

Are there any questions you may have about the materials, personnel, and/or procedures? Go to Station 1 and begin.

Appendix C

ASSESSMENT OF PRACTICE EFFECTS IN INDIVIDUALIZED TRAINING

Because of the shortage of operators to participate in the individualized training study, it was impossible to run a control group to determine the effect of practice. Although some practice obviously occurred, it is possible to show that its effect on detection and identification performance is negligible. Table C-1 shows detection and identification rights as a function of 30-minute scenario segments. Operator performance for detection rights and identification rights is presented across the 30-minute segments. Segments 1, 2, 5, and 6 are low-target-activity segments, and segments 3, 4, 7, and 8 are high-activity segments.

Table C-1

Detection and Identification Rights

	Session I			Session II			Total number of rights
	30-minute segments in order administered			30-minute segments in order administered			
	1	3		5	7		
	2		4	6		8	
Detection rights							
Odd segments	51	58		52	75		236
Even segments	31		68	39		80	218
Identification rights							
Odd segments	43	46		50	64		203
Even segments	27		50	35		68	180

For learning or practice effects to have taken place, the total number of rights for the even-numbered segments would have to be greater than the total number for the odd-numbered segments (assuming equal target difficulty over all segments). However, for both detection and identification rights, the total number of rights for the even-numbered segments is below that for the odd-numbered segments. These results strongly support the contention that practice or learning effects did not have an important impact on the operator performance increases and that, therefore, these increases are due to the training.

In addition, previous research (Martinek, Pilette, and Biggs, 1974) has shown no increases in performances associated with 8 hours of practice on scenarios highly similar to those used in this study. Moreover, the operators used in that study had just graduated from school and, therefore, should show the largest increases attributable to practice (i.e., experience).

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