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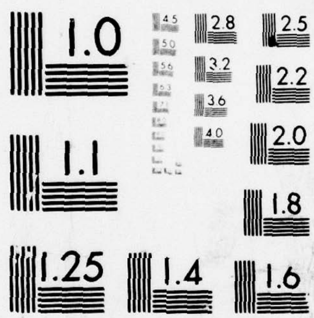
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TECHNICAL PAPER 377

LEVEL II

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THE EFFECT OF SIGNAL/NOISE RATIO AND BANDWIDTH ON VEHICLE IDENTIFICATION, USING THE ACOUSTIC SENSOR

Harold Martinek
ARMY RESEARCH INSTITUTE FOR THE BEHAVIORAL AND SOCIAL SCIENCES

and

Sterling S. Pilette and Bill E. Biggs
HRB-SINGER, INCORPORATED

HUMAN FACTORS TECHNICAL AREA

U. S. Army
Research Institute for the Behavioral and Social Sciences

June 1979

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FOR THE BEHAVIORAL AND SOCIAL SCIENCES

A Field Operating Agency under the Jurisdiction of the Deputy Chief of Staff for Personnel

JOSEPH ZEIDNER
Technical Director

WILLIAM L. HAUSER
Colonel, US Army
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Three experiments were conducted to determine the effect of variations in signal-to-noise (S/N) ratio and increased bandwidth on the ability of remotely monitored sensor operators using the acoustic sensor to identify vehicles in convoy. In general, the operator was to discriminate between the following seven military vehicles traveling in typical convoys: jeeps, gamma goats, 2-1/2-ton trucks, 5-ton trucks, 10-ton trucks, armored

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personnel carriers, and tanks. Targets were presented at each of four levels of S/N ratio: +6 decibels (dB), +12 dB, +18 dB, and +24 dB. The operational bandwidth of 50-2000 hertz (Hz) was compared to that of 50-4500 Hz. Special training under all of the above conditions was given.

The results indicate that operator identification completeness declines as the S/N ratio decreases approximately 1% per 1.5 dB of S/N ratio. No differences were found in use of the two bandwidths. Use of automatic gain control should be limited because the operator uses loudness variations to discriminate among targets.

TECHNICAL PAPER 377

THE EFFECT OF SIGNAL/NOISE RATIO AND BANDWIDTH ON VEHICLE IDENTIFICATION, USING THE ACOUSTIC SENSOR

Harold Martinek
ARMY RESEARCH INSTITUTE FOR THE BEHAVIORAL AND SOCIAL SCIENCES

and

Sterling S. Pilette and Bill E. Biggs
HRB SINGER, INCORPORATED

Submitted by:
Edgar M. Johnson, Chief
HUMAN FACTORS TECHNICAL AREA

Approved By:

A.H. Birnbaum, Acting Director
ORGANIZATIONS AND SYSTEMS
RESEARCH LABORATORY

Joseph Zeidner
TECHNICAL DIRECTOR

U.S. ARMY RESEARCH INSTITUTE FOR THE BEHAVIORAL AND SOCIAL SCIENCES
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Sensor Systems
Integration and Utilization

ARI Research Reports and Technical Reports are intended for sponsors of R&D tasks and for other research and military agencies. Any findings ready for implementation at the time of publication are presented in the last part of the Brief. Upon completion of a major phase of the task, formal recommendations for official action normally are conveyed to appropriate military agencies by briefing or Disposition Form.

FOREWORD

The Human Factors Technical Area is concerned with the human resource demands of increasingly complex battlefield systems which are used to acquire, transmit, process, disseminate, and utilize information. Research in this area focuses on human performance problems related to interactions within command-and-control centers as well as issues of system development. It is concerned with such areas as software development, topographic products and procedures, tactical symbology, user-oriented systems, information management, staff operations and procedures, decision support, and sensor systems integration and utilization.

One area of special interest is that of human factors problems in 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 also such information as the direction and speed of convoys and personnel, the number of vehicles in convoy, and the composition of the convoy, e.g., armored versus wheeled vehicles.

The research presented in this report investigated the effect on operator performance of various levels of signal-to-noise ratio and also extended previous research on operator bandwidth requirements for the acoustic remote sensor. The results have implications for overall sensor system design and for the operational utilization of varying numbers of relays.

Research on 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. This report represents research by personnel from ARI and HRB Singer, Inc., under contract DAHC19-76-C-0034. The effort is responsive to general requirements of Army Project 2Q763743A774 and to special requirements of the U.S. Army Intelligence Center and School, Fort Huachuca, Ariz.; Project AVID GUARDIAN, U.S. Army, Europe; and the Remotely Monitored Battlefield Sensor System (REMBASS) project. Special requirements are contained in Human Resource Need 77-120, Target Acquisition and Classification Using Information

Obtained from Unattended Ground Sensors (UGS) and 78-93, Operator Training and Aids for Interpretation of Acoustic Sensor.

JOSEPH ZEIDNER
Technical Director

THE EFFECT OF SIGNAL/NOISE RATIO AND BANDWIDTH ON VEHICLE IDENTIFICATION, USING THE ACOUSTIC SENSOR

BRIEF

Requirement:

To determine the effect of variations of signal-to-noise (S/N) ratio on the ability of remotely monitored sensor (REMS), formerly called unattended ground sensor (UGS), operators to identify vehicles in convoy.

To determine the effect of an increase in bandwidth on the REMS operator's ability to identify vehicles.

Procedure:

Three experiments were conducted: S/N Ratio, Individual Target, and Bandwidth. In the S/N Ratio Experiment, 20 operators received special training, which covered four levels (+6 decibels (dB), +12 dB, +18 dB, and +24 dB) of S/N ratio. After training, magnetic tape recordings simulating REMS outputs were used to determine the operators' ability to identify military vehicles in convoys. Seven vehicle types were present in the convoys: jeeps, gamma goats, 2-1/2-ton trucks, 5-ton trucks, 10-ton trucks, armored personnel carriers, and tanks. The test tapes were made from recordings collected in field maneuvers of armored and motorized infantry units. A 4 x 4 Graeco-Latin Square design was used to counterbalance the variables of S/N ratios, operator groups, order of presentation, and convoys.

The Individual Target Experiment presented operators with individual targets using only vehicle sounds that had similar signal strength (±2 dB difference). The operators interpreted sounds of each vehicle type at each of the four S/N ratios in a randomized sequence.

In the Bandwidth Experiment, the operators were given convoy sound recognition training using both 50-2000 hertz (Hz) and 50-4500 Hz bandwidths. They were then tested on their ability to identify military vehicles in convoys at both bandwidths using a 2 x 2 x 4 modified Latin Square design. The variables of this design are bandwidth, order of presentation, and operator groups.

Findings:

Operator identification completeness tends to decline as the S/N ratio decreases approximately 1% per 1.5 dB of S/N ratio.

Operator identification completeness of light- and medium-wheeled vehicles tends to increase as the S/N ratio decreases. This unusual relationship results from a tendency to report (i.e., to guess) these vehicle types more frequently as noise increases. However, accuracy in reporting light- and medium-wheeled vehicles tends to decrease as noise increases.

Operator identification completeness of 5-ton trucks, 10-ton trucks, and tracked vehicles declines as the S/N ratio decreases.

The 50-4500 Hz bandwidth provides no advantage to identification over the currently used 50-2000 Hz bandwidth.

Utilization of Findings:

Field commanders, training personnel, and operators should be made aware of the tendency of operators under high noise conditions (such as many relays) to identify any vehicle sounds as light- and medium-wheeled vehicles. Specific training to counteract this effect should be given both in the school and on the job.

From the standpoint of signal interpretability, there is no requirement for new acoustic sensors to use a greater bandwidth than the current one of 50-2000 Hz.

For purposes of developing doctrine for the employment of relays and designing new acoustic sensors, this rule of thumb can be used: A 1% decrease in operator performance will occur for every 1.5 dB loss in S/N ratio.

Use of automatic gains control should be limited to allow signal loudness variations between vehicle types.

THE EFFECT OF SIGNAL/NOISE RATIO AND BANDWIDTH ON VEHICLE IDENTIFICATION, USING THE ACOUSTIC SENSOR

CONTENTS

LIST OF TABLES

The operators' task is difficult but not impossible, as evidenced by the results of previous research that used an S/N ratio of about +36 dB.[2] Following training, operators in previous research detected 92% of the convoy vehicles and correctly placed 76% of these into the appropriate categories of wheeled and tracked vehicles. Those results are based upon use of a continuous transmission concept, i.e., an acoustic sensor having the capability to transmit continuously from the beginning to the end of a convoy. Using the intermittent transmission concept, an identifications performance of 81% correct was achieved.

The continuous transmission concept increases the amount of information available to the operator over the current acoustic sensor concept as represented by the operational Audio Add-on Unit (AAU). The AAU, slaved to the Miniaturized Seismic Intrusion Device (MINISID III), transmits 15 seconds of audio after three seismic activations have occurred within a 28-second time period. The drawback with the AAU is a minimum 20-second inhibit time between 15-second transmissions, resulting in an automatic 50% information loss in the case of convoys.

The current research used the continuous transmission concept because devices of this kind might be affected more by S/N ratio, and with regard to engineering, might be easier to produce and use in the field than intermittent REMS. In addition, the results of such research can be applied to the AAU type of sensor by assuming that they apply only to the time when the AAU would actually be transmitting.

The bandwidth of the audio signal is another variable that might affect operator performance and should be considered in the design of future systems. The current approach for new acoustic sensors is to use the same frequency range as the AAU (50-2000 Hz). An exploratory experiment of bandwidth (Martinek, Pilette & Biggs, 1978) suggested that the 50-1500-Hz range is inferior to the current 50-2000-Hz range, but the experiment was inconclusive in comparing the 50-2000-Hz range and the 50-4000-Hz range.

Objectives

The objectives of the research reported here were

1. To measure the performance of trained REMS operators using signals from the acoustic sensor at different S/N ratios to identify individual vehicles in a convoy.

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[2] Martinek, H., Pilette, S., & Biggs, B. Vehicle Identification Using the Acoustic Sensor: Training, Sensing Concepts, and Bandwidth. ARI Technical Paper 334, September 1978.

2. To determine if increased bandwidth (50-4500 Hz) results in increased information output from the operator.

METHOD OF INVESTIGATION

Population and Sample

The population of concern is the Army enlisted operator (MOS 17M20), school-trained at the U.S. Army Intelligence Center and School (USAICS). Twenty of these operators, from the Remote Sensor Platoon of the 101st Airborne Division, Fort Campbell, Ky., participated in the experiment.

Apparatus

Two Uher[3] tape recorders (4400), a feeder box, 11 headsets, and necessary electronic connections were used. The feeder box enabled up to 11 people (10 operators and 1 facilitator) to listen to the training and the test scenarios at the same intensity level.

Independent Variables

The independent variables will be discussed separately for each of the three experiments reported in this paper: S/N Ratio Experiment, Individual Target Experiment, and Bandwidth Experiment.

1. S/N Ratio Experiment

   a. S/N Ratio--Four S/N ratio levels were used to represent the expected range of S/N ratios in future systems: +6 dB, +12 dB, +18 dB, and +24 dB. The S/N ratio levels were achieved by adding white noise to the taped convoy signals. (See Appendix A for details of the procedure.)

   b. Scenario--Four scenarios, each composed of tape recordings of the sounds of vehicles in convoy, were used. Each scenario was composed of six convoys matched on convoy type (wheeled, tracked, or mixed) and total number of vehicles. Each scenario was presented with each S/N ratio.

   c. Groups--Five operators were assigned to each of four groups.

---

[3] The commercial designation is used for purposes of specific identification of the equipment and does not constitute endorsement by the Army Research Institute or by the Army.

d. Periods--There were four time periods in which each group was presented a different scenario and S/N ratio combination.

e. Target Type--Although not statistically analyzed as an independent variable, the data were examined in terms of the various target types used. The seven target types were

1. jeep (JP),
2. gamma goat (GG),
3. 2-1/2-ton truck (2-1/2T),
4. 5-ton truck (5T),
5. 10-ton truck (10T),
6. armored personnel carrier (APC), and
7. tank (TNK).

These target types typically vary in signal strength and represent the types of vehicles of interest to the commanders.

2. Individual Target Experiment

a. S/N Ratio--The same four S/N ratios were used as in the S/N Ratio Experiment--+6 dB, +12 dB, +18 dB, and +24 dB.

b. Target Type--Seven target types were analyzed--(1) JP, (2) GG, (3) 2-1/2T, (4) 5T, (5) 10T, (6) APC, and (7) TNK. These targets were presented singly and at about the same signal strength (within ±2 dB).

3. Bandwidth Experiment

a. Bandwidth--Two bandwidths were used--50-2000 Hz and 50-4500 Hz.

b. Groups--Ten operators were assigned to each of two groups.

c. Periods--There were four consecutive time periods in which convoy sounds were presented to assess time effects (particularly practice).

Dependent Variables

One dependent variable measured was the percent of vehicles presented that were identified correctly, hereinafter called identification completeness. Identification completeness was obtained for each of four levels of target detail. One level, the seven vehicle categories mentioned under Target Type (1e) above, is called the seven-target category. The operators' reports were also scored using three other related sets of categories, shown in Table 1. Under this concept, detection completeness is considered the lowest level of target detail required of the operator (note in Table 1, 1-target--vehicle detections).

Table 1

Four Levels (Categories) of Identification Completeness

Categories	Target types						
7-target	JP	GG	2-1/2T	5T	10T	APC	TNK
5-target	Light-wheeled		Medium-wheeled	Heavy-wheeled		APC	TNK
2-target	Wheeled					Tracked	
1-target	Vehicle detections						

Another independent variable measured was target accuracy. The percentage of identification accuracy was obtained by dividing the number of correctly identified vehicles (rights) by the total number of vehicles reported (rights and wrongs).

Experimental Designs

1. S/N Ratio Experiment--The experimental design is four-factor, Graeco-Latin Square design (see Table 2). The four independent variables and their levels as discussed earlier are:

   a. S/N Ratio--+6 dB, +12 dB, +18 dB, and +24 dB,

   b. Scenarios--A, B, C, and D,

   c. Periods--1, 2, 3, and 4,

   d. Groups--1, 2, 3, and 4.

Each group of operators is tested on each scenario, and each S/N ratio across periods, so that the same S/N ratio is never paired with the same scenario more than once (see Table 2).

Table 2

Experimental Design--Signal/Noise Ratio Experiment

Group	Period 1	Period 2	Period 3	Period 4
Group 1 (Op 1-5)	Scenario A +6 dB	Scenario B +18 dB	Scenario C +24 dB	Scenario D +12 dB
Group 2 (Op 6-10)	Scenario B +12 dB	Scenario A +24 dB	Scenario D +18 dB	Scenario C +6 dB
Group 3 (Op 11-15)	Scenario C +18 dB	Scenario D +6 dB	Scenario A +12 dB	Scenario B +24 dB
Group 4 (Op 16-20)	Scenario D +24 dB	Scenario C +12 dB	Scenario B +6 dB	Scenario A +18 dB

The Graeco-Latin Square design assumes that there are no interactions between the independent variables. The assumption is valid if there is not a significant residual effect. If the residual effect is significant, then a significant difference found for an independent variable might be due to the interaction of two or more of the other variables.

2. Individual Target Experiment--The experimental design for this experiment is a two-factor, repeated-measures design (see Table 3). Each operator saw each target type at each of four S/N ratio levels and in the same order. The order of presentation (not shown in the table) of the four levels of S/N ratio and four different sound samples of each target type was randomized.

3. Bandwidth Experiment--The experimental design for the Bandwidth Experiment is a three-factor Latin Square design (see Table 4). Group 1 received, during Periods 1 and 2, Battalions (BN) 1 and 2 at the 50-4500-Hz level. They received BNs 2' and 1' at the 50-2000-Hz level during Periods 3 and 4. Group 2 received the reversal of this treatment. The independent variables are bandwidth, period, and groups. To permit a more effective assessment of practice, one factor (period) of the 2 x 2 Latin Square was expanded from two periods into four periods.

Table 3

Experimental Design--Individual Target Experiment

Targets	JP	GG	2-1/2T	5T	10T	APC	TNK
S/N ratio (dB)	+6,+12 +18,+24	+6,+12 +18,+24	+6,+12 +18,+24	+6,+12 +18,+24	+6,+12 +18,+24	+6,+12 +18,+24	+6,+12 +18,+24
Operators (1-20)	(All operators received all conditions)						

Table 4

Experimental Design--Bandwidth Experiment

Group	Period 1	Period 2	Period 3	Period 4
Group 1 (Op 1-10)	50-4500 Hz BN1[a]	50-4500 Hz BN2	50-2000 Hz BN2'	50-2000 Hz BN1'
Group 2 (Op 11-20)	50-2000 Hz BN2'	50-2000 Hz BN1'	50-4500 Hz BN1	50-4500 Hz BN2

[a]BN = battalion.

Training

1. S/N Ratio Experiment--A training approach using short instructional units was developed to familiarize the operators with the various vehicle sounds under the conditions of the four S/N ratios. The training was composed of the following parts:

a. Section A--Convoy Sound Recognition Training

(1) Part 1--Vehicle-Pairs Comparison

(2) Part 2--Continuous Sound With Closest-Point-of-Approach (CPA) Feedback

b. Section B--Background Noise Training

(1) Part 1--Low Background Noise (+24-dB S/N ratio)

(2) Part 2--Medium/Low Background Noise (+18-dB S/N ratio)

(3) Part 3--Medium/High Background Noise (+12-dB S/N ratio)

(4) Part 4--High Background Noise (+6-dB S/N ratio)

(5) Part 5--Continuous Sound Practice
Convoys 1, 2, 3, and 4

The complete training script is presented in Appendix B, Facilitator Guide. The essential parts of the script together with the convoy sounds were recorded on tape for controlled presentation to the operators.

Basically, the training consisted of single-sound presentations followed by practice and feedback with convoys. The vehicle-pairs comparison portion of the training (Section A, Part 1) presented two sounds of the same target type to the operator, followed by two sounds of another target type. This permitted the operator to make quick comparisons of the various sound characteristics of the same and different target types. The remaining instruction units (parts) presented four sound samples of each vehicle type, followed by immediate practice using two convoy exercises. The operators were required to mark their vehicle identifications on a specially prepared target log, illustrated in Appendix B, and were then given the answers so they could determine how well they were doing and where they were making errors.

After this feedback, the operators were given the same convoys to reanalyze, but with an added dimension. In Part 2 of the Convoy Sound Recognition Training, a short tone signaled when each vehicle was at the closest point of approach (CPA). This training technique enabled the operators to compare their perception of when each vehicle was at the CPA with the actual CPA. Additionally, it identified any vehicles that had been missed. During the presentation of the Background Noise Training (Section B), instead of a tone at CPA, feedback was provided by naming the vehicle.

A total of seven convoys at the 50-2000-Hz bandwidth was used for training for the S/N Ratio Experiment. Table 5 shows the vehicle composition of the training convoys. Included are wheeled, tracked, and mixed convoys.

2. Bandwidth Experiment--The training for the Bandwidth Experiment was the same as the Convoy Sound Recognition Training of the S/N Ratio Experiment except that training was presented using a 50-4500-Hz bandwidth.

3. Individual Target Experiment--The training given for both the S/N Ratio Experiment and Bandwidth Experiment served as the training for the Individual Target Experiment.

Scenario Construction

The test and training scenarios were constructed from convoys recorded during an Army field exercise at Fort Hood, Tex. This exercise involved wheeled and armored vehicles traveling singly and in convoys at speeds between 5 and 40 miles per hour (m/h). Since the convoy sounds were recorded on audiotape, test scenarios could be constructed by judicious editing to fit the experimental designs and still simulate operational conditions. Scenarios developed for a previous experiment (Martinek, Pilette, & Biggs, 1978) served as the primary data base for the current research. Additional material was obtained from the original field tapes to augment these scenarios.

Table 5

Composition of Training Convoys

Convoy # and type	Vehicle types							Total
	JP	GG	2-1/2T	5T	10T	APC	TNK	
1. Mixed (M)	2	1	0	0	0	2	3	8
2. Wheeled (W)	1	3	4	0	0	0	0	8
3. W	5	0	1	1	0	0	0	7
4. Tracked (T)	0	0	0	0	0	10	0	10
5. M	2	0	0	1	1	1	4	9
6. T	0	0	0	0	0	10	0	10
7. W	3	0	3	0	2	0	0	8
Total:	13	4	8	2	3	23	7	60

In all, 31 convoys and approximately 30 single-vehicle signals were selected for use in the three experiments. Of these 31 convoys, 20 were from the previous experiment (taped at 50-2000 Hz), and 11 were constructed from the field tapes using a longer bandwidth (50-4500 Hz).

The final choice of convoys for the S/N Ratio Experiment was based on selecting an equal number of tracked, wheeled, and mixed convoys for each of the four scenarios. Table 6 presents the vehicle composition of each convoy within the four scenarios, together with the signal dB range (high and low). Twenty-four different convoys were required for this design--six convoys (50 vehicles) per scenario. Note that in some convoys the dB range is small, whereas in others it is large. In general, a large dB range is due to the lower signal strength of light-wheeled vehicles in relation to heavy-wheeled or tracked vehicles.

Each of the scenarios was taped at the four S/N ratios at 50-2000 Hz. A technical discussion of S/N ratio and the procedures and equipment used to tape each S/N ratio is presented in Appendix A.

Table 6

Composition of Convoys--Signal/Noise Ratio Experiment

Scenario	Convoy # and type	Vehicle types							Convoy totals	Signal dB range (0 scale)	
		JP	GG	2-1/2T	5T	10T	APC	TNK		Low	High
A	1. Tracked (T)	0	0	0	0	0	6	3	9	0	0
	2. Wheeled (W)	1	0	3	4	0	0	0	8	-10	0
	3. Mixed (M)	2	0	1	0	2	4	0	9	-24	0
	4. W	1	0	0	4	0	0	0	5	-4	-1
	5. M	0	1	2	1	1	4	2	11	-2	0
	6. T	0	0	0	0	0	3	5	8	0	0
	Total:	4	1	6	9	3	17	10	50		
B	1. W	4	0	2	0	2	0	0	8	-9	-1
	2. T	0	0	0	0	0	4	4	8	0	0
	3. W	2	3	1	1	2	0	0	9	0	0
	4. T	0	0	0	0	0	6	2	8	-7	-1
	5. M	3	1	0	0	1	6	1	12	-13	0
	6. M	0	0	0	1	0	3	1	5	-3	0
	Total:	9	4	3	2	5	19	8	50		
C	1. T	0	0	0	0	0	5	5	10	-5	0
	2. M	1	0	1	6	0	3	0	11	-6	0
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	5. T	0	0	0	0	0	3	3	6	0	-2
	6. M	0	0	1	1	0	0	4	6	0	0
	Total:	11	4	3	7	2	11	12	50		
D	1. W	3	1	3	0	0	0	0	7	0	-1
	2. M	0	3	3	0	0	4	0	10	-7	0
	3. T	0	0	0	0	0	3	5	8	-1	0
	4. W	1	0	0	5	0	0	0	6	-10	-4
	5. M	1	1	1	0	4	1	3	11	-8	0
	6. T	0	0	0	0	0	3	5	8	0	0
	Total:	5	5	7	5	4	11	13	50		
	Grand Total:	29	14	19	23	14	58	43	200		

Table 7 gives vehicle composition of each convoy for each bandwidth used in the Bandwidth Experiment. The same 10 convoys were used for both the 50-2000-Hz and 50-4500-Hz bandwidth conditions, but in different sequences, so as to appear different to the operators. The 50-4500-Hz condition was prepared first and then retaped using a low band-pass filter to achieve the 50-2000-Hz condition. Each grouping of 5 convoys was standardized to include 41 vehicles.

Twenty-eight vehicles traveling alone were selected from the field tapes for the Individual Target Experiment, to provide four different samples of each target type (JP, GG, 2-1/2T, 5T, 10T, APC, and TNK) at similar signal strengths. The 28 vehicle sounds were presented to the operators randomly for each of the four S/N ratios, making a total of 112 vehicle sounds. Each vehicle sound was presented for approximately 6 seconds, followed by a 10-second pause.

Test Procedure

Each operator participated for 3 days, as Table 8 shows. During orientation, the background and purpose of the research were presented and the operators' tasks outlined. The purpose of the test procedure training was to teach the operators the procedures required for data collection. The major task required of the operations was to monitor convoy sounds and to report vehicle identifications in sequence by marking the appropriate spaces on a target log. After the test procedure training, the operators were given the S/N Ratio Experiment training. The purpose of this training was to insure that the operators were at least minimally trained and experienced in the wide range of S/N ratios employed in the research.

Day 2 consisted of the S/N ratio test, preceded by a review briefing and a continuation of S/N training. The review briefing was given to minimize any "warm-up" effects.

During Day 3 each group received, in order, the Bandwidth Experiment training, the Bandwidth Experiment test, the Individual Target Experiment briefing, and the Individual Target Experiment test.

Criteria for Scoring

With only 6 seconds to recognize and report the exact identification of a vehicle (e.g., truck, not just vehicle), the operator sometimes reported fewer vehicles than were present. If a rigid scoring key was used, all vehicle reports made after a vehicle had been missed would be out of sequence and scored as errors. If the first vehicle was missed, all reports of the remaining vehicles in the convoy would probably be scored as errors. Thus, in the cases of an omitted target in a convoy, a flexible scoring strategy was used to allow maximum credit for vehicles reported out of sequence.

Table 7

Composition of Convoys--Bandwidth Experiment

Bandwidth	Convoy sequence and type	Vehicle types							Convoy totals
		JP	GG[a]	2-1/2T	5T	10T	APC	TNK	
	1. Tracked (T)	0	0	0	0	0	6	2	8
	2. Wheeled (W)	1	0	3	4	0	0	0	8
50-4500-Hz	3. Mixed (M)	0	0	1	2	0	3	1	7
	4. T	0	0	0	0	0	10	0	10
	5. W	4	0	2	0	2	0	0	8
	Total:	5	0	6	6	2	19	3	41
	6. T	0	0	0	0	0	3	5	8
	7. W	1	0	0	4	0	0	0	5
50-4500-Hz	8. M	1	0	1	5	0	3	0	10
	9. T	0	0	0	0	0	3	5	8
	10. W	3	0	4	1	2	0	0	10
	Total:	5	0	5	10	2	9	10	41
	1. M	1	0	1	5	0	3	0	10
	2. T	0	0	0	0	0	3	5	8
50-2000-Hz	3. T	0	0	0	0	0	3	5	8
	4. W	3	0	4	1	2	0	0	10
	5. W	1	0	0	4	0	0	0	5
	Total:	5	0	5	10	2	9	10	41
	6. M	0	0	1	2	0	3	1	7
	7. T	0	0	0	0	0	10	0	10
50-2000-Hz	8. T	0	0	0	0	0	6	2	8
	9. W	4	0	2	0	2	0	0	8
	10. W	1	0	3	4	0	0	0	8
	Total:	5	0	6	6	2	19	3	41
	Grand Total:	20	0	22	32	8	56	26	164

[a]No gamma goats were used in this study.

Table 8

Schedule of Administration

Day 1	A.M. (8:00-11:30) Operators 1-10
	Orientation (10 minutes)
	Test Procedure Training (50 minutes)
	S/N Ratio Experiment Training (2 hours 30 minutes)
	Section A--Continuous Sound--No Noise (60 minutes)
	Part 1--Vehicle-Pairs (25 minutes)
	Break (10 minutes)
	Part 2--CPA Feedback (25 minutes)
	Section B--Background Noise (90 minutes)
	Part 1--Low Noise (30 minutes)
	Break (10 minutes)
	Part 2--Medium-Low Noise (25 minutes)
	Part 3--Medium-High Noise (25 minutes)
	P.M. (1:00-4:30) Operators 11-20
	(Same as above)
Day 2	A.M. (8:00-10:00) Group 1--Operators 1-5
	Review Briefing (15 minutes)
	Section B--Continued
	Part 4--High Noise (30 minutes)
	Part 5--Practice Convoys 1, 2, 3, 4 (30 minutes)
	S/N Ratio Experiment Test (35 minutes)
	A.M. (10:00-12:00) Group 2--Operators 6-10
	(Same as above)
	P.M. (12:30-2:30) Group 3--Operators 11-15
	(Same as above)
	P.M. (2:30-4:30) Group 4--Operators 16-20
	(Same as above)

Table 8 (Continued)

Day 3	<u>A.M. (8:00-10:00) Group 1--Operators 1-5</u>
	Bandwidth Experiment Training (30 minutes) Bandwidth Experiment Test (30 minutes) Break (15 minutes) Individual Target Experiment Briefing (10 minutes) Individual Target Experiment Test (35 minutes)
	<u>A.M. (10:00-12:00) Group 2--Operators 6-10</u>
	(Same as above)
	<u>P.M. (12:30-2:30) Group 3--Operators 11-15</u>
	(Same as above)
	<u>P.M. (2:30-4:30) Group 4--Operators 16-20</u>
	(Same as above)

Depending on field requirements, the combat commander might request information at different levels of detail. Generally, the more detailed the reported information, the greater the error rate. A combat commander may prefer very accurate gross information, or relatively inaccurate detailed information. For this reason, operator reports were scored using four different categories of target identification, each successively more detailed (see Table 1).

For the seven-target category, credit was given only for exact identification for each vehicle type.

For the five-target category, if an operator reported either of the vehicles under the light-wheeled category (see Table 1), it was scored as a correct identification. A similar procedure was applied for the heavy-wheeled category. For the medium-wheeled, APC, and tank targets, credit was given only to exact reports of 2-1/2T, APC, and TNK.

For the two-target category, if the operator reported any type of wheeled vehicle, and it was a wheeled vehicle, it was scored as correct. A similar procedure was applied for tracked vehicles.

For the one-target category, if the operator reported a vehicle when a vehicle was present, regardless of type, it was scored as a detection. A flexible scoring strategy was maintained throughout all four categories.

In the Individual Target Experiment, the seven, two, and one classification levels were scored the same except that the flexible scoring strategy was not needed since any omitted target was readily apparent.

RESULTS AND DISCUSSION

The results are presented in terms of the four categories of target classification (seven-, five-, two-, and one-target categories) defined earlier in the Variables section of this report. The number of correct identifications for the various treatment conditions was used to conduct the statistical analysis. However, for purposes of discussion, identification completeness scores expressed as percentages are used to enable the reader to relate the results more readily to field applications. The results are discussed in the following order: S/N Ratio Experiment, Individual Target Experiment, Implications for Automatic Gain Control, and Bandwidth Experiment.

Signal/Noise Ratio Experiment

Seven-Target Category. Table 9 presents the analysis of variance, Table 10, the mean identification completeness. Significant effects are groups, period, S/N ratio, and scenario. The residual effect is nonsignificant. This indicates that none of the significant differences above are the result of interactions between the other variables.

Table 9

Signal/Noise Ratio Experiment--Seven-Target Category
Analysis of Variance Summary Table

Source of variation	df	Sum of squares	Mean square	F	Sig level
Between subjects	19	2,279.300			
Groups	3	1,107.100	369.033	5.04	.05
Subjects b/groups	16	1,172.200	73.262		
Within subjects	60	998.500			
Period	3	140.100	46.700	5.34	.01
S/N ratio	3	111.000	37.000	4.23	.05
Scenario	3	296.700	98.900	11.32	.01
Residual	3	31.300	10.400	1.19	NS
Subject w/groups	48	419.400	8.738		
Total:	79	3,277.800			

The average percentage of identification completeness for the four groups is 25%, 28%, 21%, and 29%. A probable explanation of the poor performance of the third group is the time of day of the test: The third group participated after lunch (12:30 p.m. - 2:30 p.m.) in an un-air-conditioned test room during hot weather.

The significant scenario effect indicates that differences existed among scenarios even though they were matched in terms of the number of convoys (5 each) and total vehicles (50 each) and were somewhat similar in the numbers of each vehicle type. The significant group and scenario effects have no special importance to the objectives of the research, serving primarily as control variables.

The significant period effect apparently reflects the difference between the relatively low performance during Period 2 (22%) and performance during Periods 1, 3, and 4. Of importance is the lack of a practice effect: i.e., operators did not improve in each successive period because of practice (learning). This is important because earlier research concerning the effect of special training (Martinek, Pilette, & Biggs, 1978) using similar test conditions and subjects resulted in inconclusive results as to practice effects that would confound the results in training. The current data show no evidence of a practice effect.

Table 10

Signal/Noise Ratio Experiment--Seven-Target Category Mean Identification Completeness

S/N ratio	Period 1	Period 2	Period 3	Period 4	Mean	Sig[a] pairs
+6 dB	Scenario A	Scenario D	Scenario B	Scenario C		
	Group 1	Group 3	Group 4	Group 2		
	26%	15%	28%	21%	22%	
+12 dB	Scenario B	Scenario C	Scenario A	Scenario D		
	Group 2	Group 4	Group 3	Group 1		
	29%	15%	28%	26%	24%	
+18 dB	Scenario C	Scenario B	Scenario D	Scenario A		
	Group 3	Group 1	Group 2	Group 4		
	21%	26%	32%	38%	29%	
+24 dB	Scenario D	Scenario A	Scenario C	Scenario B		
	Group 4	Group 2	Group 1	Group 3		
	37%	32%	22%	20%	28%	
Average	28%	22%	27%	26%	26%	

[a]Significant at the .01 level.

The S/N ratio effect is significant, indicating that the degree of signal-to-noise affected operator performance. Duncan's new multiple range test was used to determine which S/N ratios are significantly different from one another.[4] Table 10 shows the average completeness percentage for each S/N ratio. The endpoints of the lines drawn at the side show which percentages are significantly different from each other at the .01 level, i.e., 22% is significantly different from 28%, 22% from 29%, 24% from 28%, and 24% from 29%.

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[4]Edwards, A. L. Experimental Design in Psychological Research (Rev. ed.). New York: Rinehart and Co., 1960, chap. 5, pp. 136 ff.

These results indicate that the two lower S/N levels tested (+6 dB and +12 dB) yielded significantly less information than the two higher S/N levels tests (+18 dB and +24 dB). There is no significant difference between the two lower S/N levels nor between the two higher S/N levels. Thus, trained operators can provide about 29% correct identifications of single vehicles in convoys at the +18-dB and +24-dB levels but only about 23% as the S/N level increases to +6 dB and +12 dB.

Five-Target Category. Table 11 presents the analysis of variance for correct identification scores. Mean identification completeness is presented in Table 12. Significant effects are the residual effect, scenario, and S/N ratio. The significant scenario effect is of no special importance to this study and will not be analyzed further. The significant residual effect indicates that these main effects may be confounded by interactions between variables. However, the similarity of results in each target category suggests that the S/N ratio effect is unconfounded.

Table 11

Signal/Noise Ratio Experiment--Five-Target Category
Analysis of Variance Summary Table

Source of variation	df	Sum of squares	Mean square	F	Sig level
Between subjects	19	1,293.438			
Groups	3	178.538	59.513	.85	NS
Subjects b/groups	16	1,114.900	69.681		
Within subjects	60	1,177.250			
Period	3	67.538	22.513	2.01	NS
S/N ratio	3	138.635	46.212	4.12	.05
Scenario	3	301.938	100.646	8.98	.01
Residual	3	131.238	43.746	3.90	.05
Subject w/groups	48	537.900	11.206		
Total:	79	2,470.688			

Duncan's new multiple range test (Edwards, 1960) conducted on the number of correct identifications is shown in Table 12. The results indicate that the two lower S/N ratios (+6 dB and +12 dB) yielded significantly less information than the two higher S/N ratios (+18 dB and +24 dB) and that there was no significant difference between the two lower S/N ratios nor between the two higher S/N ratios. This outcome is identical to that for the seven-target category. Quantitatively, these results indicate that trained operators can provide about 32% identification completeness of vehicles in convoys at the +18-dB and +24-dB levels and that there is a significant decline in performance to about 28% as the S/N ratio decreases to +12 dB and +6 dB.

Table 12

Signal/Noise Ratio Experiment--Five-Target Category
Mean Identification Completeness

S/N ratio	Period 1	Period 2	Period 3	Period 4	Mean	Sig[a] pairs
+6 dB	Scenario A Group 1 28%	Scenario D Group 3 21%	Scenario B Group 4 31%	Scenario C Group 2 26%	27%	
+12 dB	Scenario B Group 2 35%	Scenario C Group 4 16%	Scenario A Group 3 31%	Scenario D Group 1 32%	29%	
+18 dB	Scenario C Group 3 25%	Scenario B Group 1 33%	Scenario D Group 2 34%	Scenario A Group 4 41%	33%	
+24 dB	Scenario D Group 4 38%	Scenario A Group 2 38%	Scenario C Group 1 29%	Scenario B Group 3 24%	32%	
Average:	32%	27%	31%	31%	30%	

[a]Significant at the .01 level.

Two-Target Category. Table 13 presents the analysis of variance for correct identification scores. Mean identification completeness is presented in Table 14. Significant effects are S/N ratio and scenario. The significant scenario effect is of no special importance to this study and will not be analyzed further.

Table 13

Signal/Noise Ratio Experiment--Two-Target Category
Analysis of Variance Summary Table

Source of variation	df	Sum of squares	Mean square	F	Sig level
Between subjects	19	1,589.45			
Groups	3	311.64	103.88	1.29	NS
Subjects b/groups	16	1,286.80	80.43		
Within subjects	60	2,221.50			
Period	3	82.45	27.48	1.22	NS
S/N ratio	3	497.75	165.92	7.37	.01
Scenario	3	421.25	140.42	6.24	.01
Residual	3	140.05	46.68	2.07	NS
Subject w/groups	48	1,080.00	22.50		
Total:	79	3,819.95			

Duncan's new multiple range test (Edwards, 1960) conducted on the number of correct identifications at each S/N ratio is shown in Table 14. Results show that there are significant differences between every comparison except the +18-dB and +24-dB levels. The two higher S/N ratio levels (+18 dB and +24 dB) yielded similar mean identification completeness (about 62%). Both yielded significantly more information than the +12-dB level (56%) and the +6-dB level (51%). In addition, the +12-dB level yielded significantly more information than the +6-dB level. Overall, as the S/N ratio decreased, operator identification completeness decreased from an average of 62% (average of +18 dB and ±24 dB) to 56% for +12 dB and 51% for +6 dB.

Table 14

Signal/Noise Ratio Experiment--Two-Target Category
Mean Identification Completeness

S/N ratio	Period 1	Period 2	Period 3	Period 4	Mean	Sig pairs[a]
+6 dB	Scenario A Group 1 50%	Scenario D Group 3 52%	Scenario B Group 4 47%	Scenario C Group 2 55%	51%	
+12 dB	Scenario B Group 2 63%	Scenario C Group 4 39%	Scenario A Group 3 57%	Scenario D Group 1 64%	56%	
+18 dB	Scenario C Group 3 59%	Scenario B Group 1 60%	Scenario D Group 2 70%	Scenario A Group 4 66%	64%	
+24 dB	Scenario D Group 4 68%	Scenario A Group 2 70%	Scenario C Group 1 53%	Scenario B Group 3 54%	61%	
Average:	60%	55%	57%	60%	58%	

[a]Significant at the .01 level.

One-Target Category. Table 15 presents the analysis of variance results for the one-target category (or detection score). Significant effects are period, S/N ratio, and scenario. Mean identification completeness is presented in Table 16. Here, as in the seven-target category results, the data show that the significant period effect is not due to a practice effect. The significant scenario effect is of no special importance to this study.

Table 15

Signal/Noise Ratio Experiment--One-Target Category
Analysis of Variance Summary Table

Source of variation	df	Sum of squares	Mean square	F	Sig level
Between subjects	19	1,475.438			
Groups	3	224.138	74.713	.96	NS
Subjects b/groups	16	1,251.300	78.206		
Within subjects	60	1,109.250			
Period	3	117.438	39.146	4.18	.05
S/N ratio	3	148.238	49.413	5.28	.01
Scenario	3	329.238	109.746	11.73	.01
Residual	3	65.238	21.746	2.32	NS
Subject w/groups	48	449.100	9.356		
Total:	79	2,584.688			

Duncan's new multiple range test (Edwards, 1960) conducted on the number of correct identifications at each S/N ratio is shown in Table 16. The outcome of this analysis is exactly the same as with the seven-target and five-target categories. The mean identification completeness for the +6-dB and +12-dB levels is 84%, and the average identification completeness for the +18 dB and +24 dB is 88%.

Comparisons With Previous Research

Figure 1 presents the results of the S/N Ratio Experiment and the results of earlier experiments (Martinek, Pilette, & Biggs, 1978). The S/N ratio level of this earlier research was left exactly as it was collected in the field--about 36 dB. This S/N ratio was obtained by comparing the highest signal strength recorded (a tank) to the lowest signal strength recorded during a period of no target activity.

Table 16

Signal/Noise Ratio Experiment--One-Target Category
Mean Identification Completeness

S/N ratio	Period 1	Period 2	Period 3	Period 4	Mean	Sig[a] pairs
+6 dB	Scenario A Group 1 88%	Scenario D Group 3 93%	Scenario B Group 4 62%	Scenario C Group 2 88%	83%	
+12 dB	Scenario B Group 2 92%	Scenario C Group 4 66%	Scenario A Group 3 87%	Scenario D Group 1 92%	84%	
+18 dB	Scenario C Group 3 92%	Scenario B Group 1 86%	Scenario D Group 2 96%	Scenario A Group 4 78%	88%	
+24 dB	Scenario D Group 4 87%	Scenario A Group 2 94%	Scenario C Group 1 86%	Scenario B Group 3 88%	89%	
Average:	90%	85%	83%	86%	86%	

[a]Significant at the .01 level.

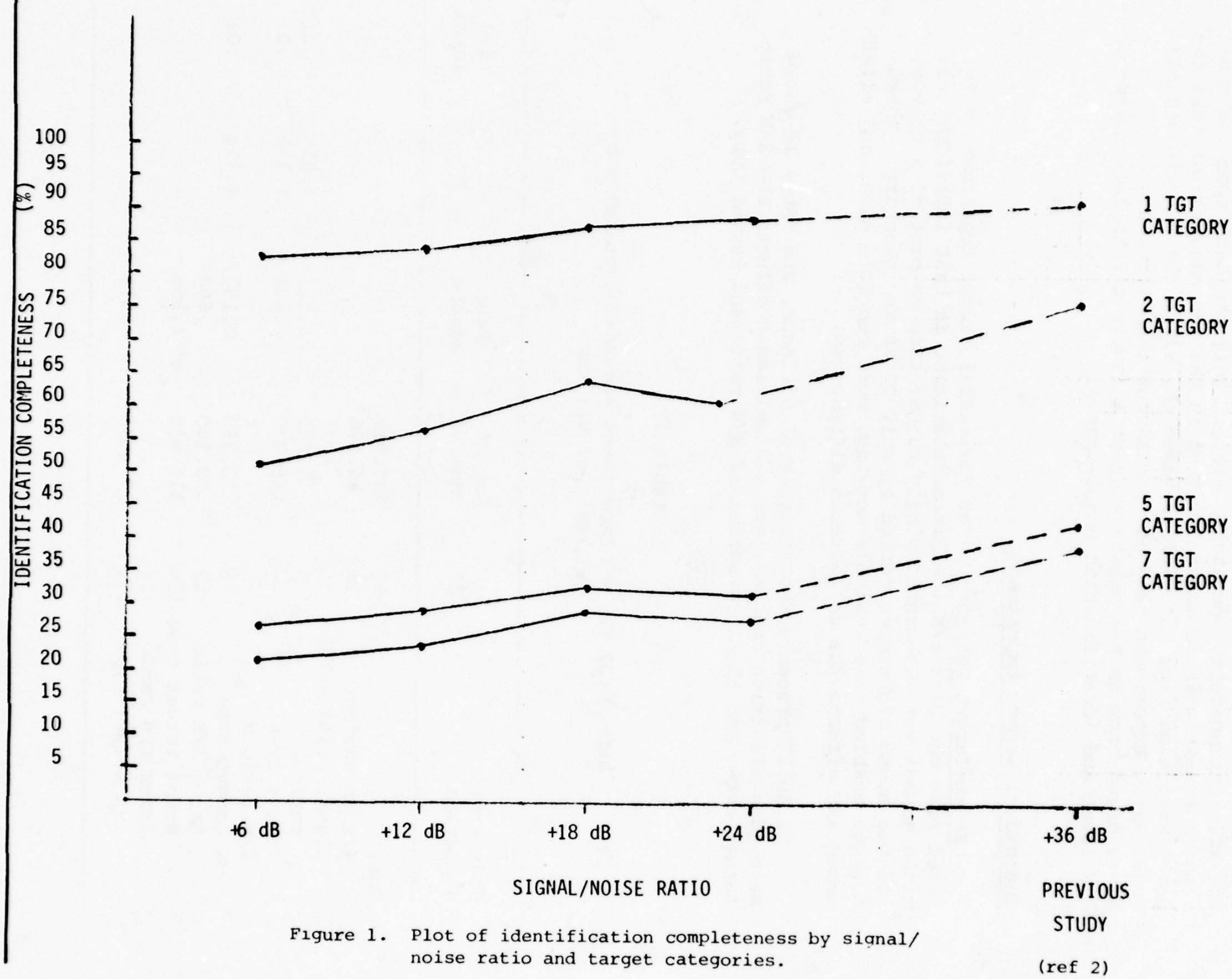


Figure 1. Plot of identification completeness by signal/noise ratio and target categories.

Except for the S/N ratios, both experiments are very similar (test scenarios, procedure, operators, etc.). Only the data from the continuous transmission concept (defined in the Introduction of this report) were used from the earlier research, since the current Signal/Noise Ratio Experiment used the continuous transmission concept. Lines drawn between the points suggest a linear relationship between S/N level and identification completeness.

Individual Target Experiment

Seven-Target Category. The Individual Target Experiment differed from the Signal/Noise Ratio Experiment in that individual vehicle sounds were presented singly rather than as part of a convoy, and the sound signatures varied by only ±2 dB in intensity. These factors enabled more reliable scoring, more complete data, and eliminated any effects due to loudness differences.

Table 17 presents the analysis of variance, and Table 18 shows mean identification completeness. Significant effects are S/N ratio, target type, and the interaction of S/N ratio and target type.

Table 17

Individual Target Experiment--Seven-Target Category
Analysis of Variance

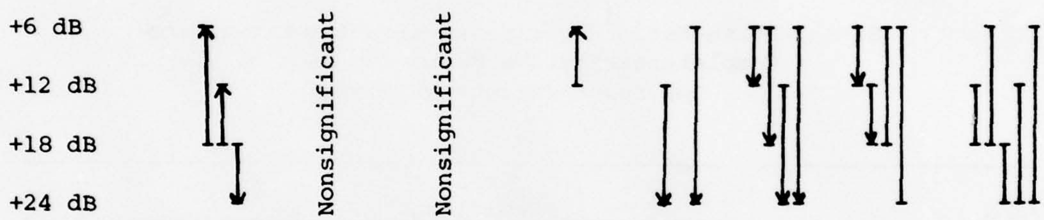
Source of variation	df	Sum of squares	Mean square	F	Sig level
Total	559	705.912			
Within subjects	19	84.376			
Signal/noise (S/N) ratio	3	9.662	3.221	4.815	.01
Target type	6	146.750	24.458	13.458	.01
S/N ratio x target type	18	38.350	2.131	4.114	.01
Error S/N ratio	57	38.160	.669		
Error target type	114	211.536	1.856		
Error S/N ratio x target type	342	177.078	.518		

Table 18

Individual Target Experiment--Seven-Target Category
Mean Identification Completeness and
Multiple Comparisons

S/N ratio	Vehicles							
	JP	GG	2-1/2T	5T	10T	APC	TNK	Mean
+6 dB	64%	25%	33%	33%	21%	31%	55%	36%
+12 dB	54%	21%	24%	21%	26%	45%	67%	36%
+18 dB	40%	20%	31%	23%	30%	54%	83%	39%
+24 dB	56%	29%	30%	25%	41%	60%	78%	44%
Mean	53%	24%	29%	25%	30%	46%	70%	39%

Multiple comparisons



The significant S/N ratio effect indicates that the degree of signal-to-noise affected operator performance. See Table 18 for the mean for each S/N ratio. Duncan's new multiple range test (Edwards, 1960) was used to determine which S/N ratios are significantly different from one another. Table 18 presents the statistically significant multiple comparisons. The end points of the lines indicate which S/N ratios are significantly different from each other. (The arrowhead points in the direction of higher identification completeness.) Operator performance at the +24-dB level was significantly higher than that at the +18-dB level, which was significantly higher than that at the +12-dB and +6-dB levels. There was no performance difference between levels at +6 dB and +12 dB. These results suggest that trained operators can provide about 44% correct identifications of single vehicles at the +24-dB level and that a significant decline in operator performance occurred to 36% correct identification as noise increased to a S/N ratio of +6 dB or +12 dB.

Identification completeness was higher than in corresponding conditions of the Signal/Noise Ratio Experiment. Single vehicle presentation is a less demanding task than convoy presentation, and the operators were tested on the same vehicle sounds used as training for the Signal/Noise Ratio Experiment.

Analysis of Individual Targets

Note that if all seven targets had been represented in equal numbers throughout the scenarios, and if all vehicles presented had been detected, 14% would be the chance level for vehicle identification. Thus, some of the identification completeness results from the Signal/Noise Ratio Experiment shown in Table 19 may appear to be at chance level or even below chance level (e.g., 10% for gamma goat). This is not the case, however, since not all vehicles were detected (some had a greater chance than others), and the proportions of vehicle types throughout the convoys and scenarios varied.

Table 19

Signal/Noise Ratio Experiment--Mean Identification Completeness by S/N Ratio for Each of the Seven-Target Categories

S/N	Vehicles							
ratio	JP	GG	2-1/2T	5T	10T	APC	TNK	Mean
+6 dB	39%	10%	37%	10%	26%	19%	19%	22%
+12 dB	27%	17%	35%	10%	20%	17%	39%	24%
+18 dB	21%	14%	33%	19%	36%	34%	34%	29%
+24 dB	25%	11%	29%	21%	34%	26%	38%	28%
Mean	28%	13%	33%	15%	29%	24%	32%	26%

The significant interaction between target type and S/N ratio in the analysis of variance of the Individual Target Experiment (see Table 17) indicates that there are performance differences between various target types as a function of S/N ratio. In general, performance on quieter vehicles, 2-1/2 ton or less, appears to be different from performance on louder vehicles, i.e., the 10-ton, APCs, and tanks. In the case of jeeps (the quietest vehicle), the +6-dB and +12-dB levels resulted in significantly better performance than the +18-dB level. This unusual effect is compounded because the +24-dB level also yielded significantly better performance than the +18-dB level. Signal/noise ratio had no significant effect on the identification of gamma goats and 2-1/2 ton trucks. For 5-ton trucks, the +6-dB level resulted in significantly higher performance than the +12-dB level. Otherwise, performance was relatively constant for this vehicle. The results for the Signal/Noise Ratio Experiment shown in Table 19 are similar for jeeps and gamma goats but tend to decrease for 2-1/2-ton trucks and increase for 5-ton trucks as the S/N ratio increases.

The results for the 10-ton truck and tracked vehicles (the louder vehicles) show the expected increase in performance as S/N ratio increases.

For the 10-ton truck (see Table 18), both the +6-dB and +12-dB ratios resulted in significantly lower identification completeness than the +24-dB ratio. For both the APC and tank, identification results significantly declined as S/N ratio decreased--from +24 dB to +6 dB, from +18 dB to +6 dB, and from +12 dB to +6 dB. In the case of the APC, another significant difference was obtained between +24 dB and +12 dB and for the tank, between +18 dB and +12 dB. The results for the S/N Ratio Experiment (see Table 19) show the same trends for these three types, i.e., an increase in performance with an increase in S/N ratio.

From both the Individual Target Experiment and Signal/Noise Ratio Experiment, the data suggest that for jeeps, performance tends to improve, and for gamma goats, 2-1/2-ton trucks, and 5-ton trucks, performance tends to improve or to be constant (with some variations) as S/N ratio decreases. However, as the weight and size of the vehicle increase (to 10-ton, APC, and TNK), performance decreases as S/N ratio decreases. These opposite trends tend to cancel each other, resulting in smaller differences between the S/N ratio levels than originally expected.

An error analysis was conducted on the data from the Individual Target Experiment in an effort to determine why performance did not decrease for all the vehicles, as would be expected when S/N ratio decreased. Table 20 gives comparison of operator reports by target type presented. The cells enclosed with thicker lines show the correct number of identifications (or "rights"). Horizontally, the numbers outside the cells are the frequencies of misidentifications (or "wrongs") for each target type at each of the four S/N ratios. Vertically, the numbers outside the cells indicate the frequency with which operators used (guessed at) a particular target type when the correct target type was misidentified. These are also presented for each of the four S/N ratios.

Table 20 shows a decided tendency for operators to guess light (quiet) vehicles more often than heavy (noisy) vehicles. This tendency for individuals to respond in a certain way is called a response set. To examine the extent of a possible response set in more detail, the number of misidentifications for each target type reported were summed

Table 20

Error Matrix for Individual Target Experiment

Target type presented	S/N ratio	Operator report							Total reports
		JP	GG	2-1/2T	5T	10T	APC	TNK	
	+6 dB	51	11	5	6	2	3	2	80
	+12 dB	43	15	12	7	0	1	0	78
JP	+18 dB	32	23	17	3	0	0	0	75
	+24 dB	45	12	12	8	0	1	0	78
	Total:	171	61	46	24	2	5	2	311
	+6 dB	23	20	14	9	6	2	4	78
	+12 dB	20	17	15	16	9	1	2	80
GG	+18 dB	29	16	13	11	8	1	0	78
	+24 dB	8	23	13	17	14	3	0	78
	Total:	80	76	55	53	37	7	6	314
	+6 dB	27	9	26	9	5	1	2	79
	+12 dB	29	11	19	9	6	2	1	77
2-1/2T	+18 dB	16	12	25	9	12	3	3	80
	+24 dB	8	14	24	14	12	4	1	77
	Total:	80	46	94	41	35	10	7	313
	+6 dB	9	12	24	26	2	4	3	80
	+12 dB	16	15	17	17	5	2	8	80
5T	+18 dB	13	10	21	18	6	5	6	79
	+24 dB	6	6	18	20	6	7	14	77
	Total:	44	43	80	81	19	18	31	316
	+6 dB	16	16	9	12	17	4	4	78
	+12 dB	14	10	15	12	21	6	1	79
10T	+18 dB	5	12	9	18	24	5	5	78
	+24 dB	10	7	7	15	33	1	7	80
	Total:	45	45	40	57	95	16	17	315
	+6 dB	11	5	6	3	1	25	29	80
	+12 dB	10	3	2	1	4	36	20	76
APC	+18 dB	7	3	0	1	0	43	26	80
	+24 dB	4	1	0	2	3	48	19	77
	Total:	32	12	8	7	8	152	94	313
	+6 dB	8	5	4	6	4	1	30	58
	+12 dB	1	3	3	3	3	6	40	59
TNK[a]	+18 dB	0	0	2	0	4	4	50	60
	+24 dB	1	0	0	2	3	7	47	60
	Total:	10	8	9	11	14	18	167	237
Total Misidentifications:		291	215	238	193	115	74	157	

Note. Correct identifications are in heavy-lined boxes; remainder are misidentifications.

[a]The data on one tank sound signature were deleted, since the tank was a different type (Sheridan) than the other three. Therefore, the maximum number of tanks presented is 60, as compared to 80 for other vehicles.

at each S/N ratio over all target types presented. Table 21 presents the results as percentages of misidentifications (number of misidentification divided by the total number of misidentifications for that vehicle).

Table 21

Percentage of Misidentifications by Target Type and S/N Ratio

S/N ratio	JP	GG	2-1/2T	5T	10T	APC	TNK
+6 dB	32%	27%	26%	23%	17%	20%	28%
+12 dB	31%	27%	27%	25%	23%	24%	20%
+18 dB	24%	28%	26%	22%	26%	24%	25%
+24 dB	13%	19%	21%	30%	33%	31%	26%

As shown, operators have a definite tendency to wrongly guess light vehicles (particularly jeeps) more often as S/N ratio decreases. This tendency becomes less pronounced as the loudness (and weight) of the vehicles becomes greater, until it reverses with the 5-ton truck; there, operators tend to guess 5-ton more at the higher S/N ratio (+24 dB). This reversal is very strong for the 10-ton truck and APCs, and it is present for the tank, but it is not clear cut due to the results at +6 dB. A possible explanation for this response set is that operators expect lighter-weight vehicles to be quieter, and when 10-ton truck and APC sounds are masked by high noise, operators tend to perceive them as lighter-weight vehicles. Similarly, under low-noise conditions, there is a tendency to report (wrongly) the heavier vehicles. The tendency for operators to report (guess) quiet vehicles under high-noise conditions and loud vehicles under low-noise conditions is a response set which lowers the operational value of this report.

Table 22 provides additional evidence to support this interpretation. These results were compiled by first summing the number of misidentifications for each target type reported for each S/N ratio. Then, the number of right identifications was divided by the number of right identifications plus the number of misidentifications. These data, converted to percentages, give identification accuracy. (Rights divided by total number of responses for that target type and S/N ratio.) Accuracy figures tend to eliminate the effects of the operator response set.

Table 22

Individual Target Experiment--Mean Identification Accuracy by Target Type and S/N Ratio

S/N ratio	Vehicle JP	GG	2-1/2T	5T	10T	APC	TNK[a]	Mean
+6 dB	25%	26%	30%	37%	46%	62%	41%	38
+12 dB	32%	23%	23%	26%	44%	67%	56%	39
+18 dB	31%	21%	29%	30%	44%	70%	56%	40
+24 dB	55%	37%	32%	26%	46%	68%	53%	45

[a]Underestimates--see footnote a in Table 20.

Generally there is little variation in accuracy across S/N ratios except for jeeps, gamma goats, APCs, and tanks. The highest accuracies for jeeps and gamma goats clearly occur at the +24-dB S/N ratio while the lowest accuracies for APC and tank occur at the 6-dB S/N ratio. Mean identification accuracy across target types shows the expected increase in performance with increase in S/N ratio.

According to the data in Table 20, operators' misidentification of a given target type tended to be a vehicle similar in terms of loudness, and in the direction of the quieter vehicles. Thus, for jeep targets, the rank order of the misidentifications of jeeps was gamma goats, 2-1/2-ton and 5-ton with very few misidentifications for the rest. Similarly, for the gamma goat targets, most misidentifications were reports of jeeps (a quieter vehicle), then 2-1/2-ton, 5-ton, 10-ton, etc. Other factors besides sound intensity are operating, as indicated by the previous discussions on S/N ratio and by a tendency to report jeeps (even for an APC, which is much louder and a tracked vehicle). Another unusual problem is the 5-ton truck, for which a disproportionately large number of tank misidentifications were found.

Thus, several factors are operating that should be considered in future training--changes in response set due to S/N ratio, a tendency to report jeeps, likelihood of reporting vehicles "close" to the true vehicle, and in some cases a tendency to report tanks.

As Table 23 shows, the results of the five-target category of the Signal/Noise Ratio Experiment are consistent with the above. The five-target category was not scored for the Individual Target Experiment. There is a tendency for the identification completeness of light-wheeled vehicles (jeeps and gamma goats combined) and the 2-1/2-ton truck to improve as S/N ratio decreases. There is also a tendency for performance on heavy-wheeled vehicles (5-ton and 10-ton trucks combined) to decrease as S/N ratio decreases. The APC and tank results are the same as those for the seven-target category with the same tendency as the heavy-wheeled vehicles. Statistical tests of significance were not conducted on these data.

Table 23

Signal/Noise Ratio Experiment--Mean Identification Completeness by S/N Ratio for Each of the Five-Target Categories

	Vehicle categories					
S/N ratio	Light-wheeled JP & GG	Medium-wheeled 2-1/2T	Heavy-wheeled 5T & 10T	APC	TNK	Mean
+6 dB	42%	37%	25%	19%	19%	28%
+12 dB	32%	35%	26%	17%	39%	30%
+18 dB	31%	33%	34%	34%	34%	33%
+24 dB	28%	29%	41%	26%	38%	32%
Averages	33%	34%	32%	24%	32%	31%

Two-Target Category. Table 24 presents the results of the two-target category of the Individual Target Experiment. As shown, an average of 92% of the wheeled vehicles and 78% of the tracked vehicles were identified correctly. S/N ratio did not seem to affect operator performance for the wheeled vehicle category but did for the tracked vehicle category. For the tracked vehicles, the +24-dB and +18-dB levels resulted in an overall average of 88%, which declined to 62% at the +6-dB level.

The results of the Signal/Noise Ratio Experiment (see Table 25) convoy data are similar to the results of the Individual Target Experiment. The wheeled vehicles produced a somewhat consistent average of about 68%. As with the Individual Target Experiment, the tracked vehicle data show a decrease in performance from the high S/N ratio levels to the low.

The results of both experiments show that the operators tended to guess the quieter vehicles (wheeled) when a vehicle sound (whether wheeled or tracked) was attenuated by noise. The operators probably responded to the signal in terms of the background noise: under high-noise conditions the signal appears to be less in intensity, leading operators to conclude that a lighter vehicle (less sound intensity) is producing the signal.

Table 24

Individual Target Experiment--Mean Identification Completeness by S/N Ratio for Each of the Two-Target Categories

S/N ratio	Wheeled vehicles	Tracked vehicles	Mean
+6 dB	93%	62%	78%
+12 dB	94%	76%	85%
+18 dB	93%	88%	90%
+24 dB	90%	88%	89%
Average		78%	85%

Table 25

Signal/Noise Ratio Experiment--Mean Identification Completeness by S/N Ratio for Each of the Two-Target Categories

S/N ratio	Wheeled vehicles	Tracked vehicles	Mean
+6 dB	71%	32%	51%
+12 dB	67%	44%	56%
+18 dB	69%	59%	64%
+24 dB	68%	54%	61%
Average	68%	47%	58%

Operator performance in the Individual Target Experiment is much higher than in the S/N Ratio Experiment, largely because of the relative ease of the operator's task with individual presentation of the vehicles rather than presentation as part of a convoy. This is consistent with results of the experiment (Martinek, Pilette, & Biggs, 1978) in which the intermittent acoustic sensor was superior to the continuous sensor.

One-Target Category. For the target category of the Individual Target Experiment, detection completeness was about 98%. A high result was expected, since the vehicle sounds were presented individually. The few cases in which no detections were made occurred primarily in the low S/N ratio conditions. For the convoy data of the Signal/Noise Ratio Experiment, the overall average is 86%.

Implications for Automatic Gain Control

The results of the preceding two experiments suggest that, in addition to using other characteristics of sound (such as pitch and timbre), operators are using sound intensity (loudness) as a major cue in identifying vehicles. Additional analyses of this effect were made using performance data on vehicle targets from a previous experiment.[5] The data were judiciously selected to provide performance in two categories of targets: high signal strength (loud) and low signal strength (relatively quiet) vehicle sounds. In this experiment, operators had been presented with single vehicle sounds of high S/N ratio (but not measured). Table 26 presents identification completeness results.

Table 26

Identification Completeness for High and Low Signal Strength Vehicle Targets

Signal strength	Vehicle: JP	GG	2-1/2T	5T	10T	APC	TNK	Average
High	3%	18%	35%	16%	36%	41%	80%	33%
Low	24%	37%	44%	17%	19%[a]	67%	76%	41%

Note. For all but one sample, n = 5.

[a] n = 3.

Assuming that noise was constant across both high and low recordings, these data indicate that low signal strength and, thus, relatively low S/N ratio results in higher mean identification completeness than high signal strength (41% and 33%, respectively).

[5] Pilette, S. S., Biggs, B., & Martinek, H. Target Identification Training for the Acoustic Sensor Operator. ARI Research Memorandum 79-4, 1979.

The trend shows higher identification completeness for the light-wheeled vehicles in the low signal strength condition. As the weight (and size) of the vehicles increases, signal strength has less effect (i.e., no difference for the 5-ton truck). However, the 10-ton truck and perhaps the tank show higher completeness for the high signal strength condition. The APC shows a reversal, unless tank and APC are considered a separate class (tracked), and the APC is the lighter vehicle in that class. Thus, this independent set of data indicates the same operator response set as previous experiments.

Since operators are basing their identifications to some degree on loudness, automatic gain control (AGC) in which the sensor automatically adjusts loudness to a constant level (whatever the vehicle type) is not advisable. However, AGC that prevents distortion but still provides a reasonable range of loudness would be advisable. In any case, operator training must take into account this aspect of operator behavior.

Bandwidth Experiment

The results of the Bandwidth Experiment are presented in terms of four target categories--six-, five-, two-, and one-target categories. A six-target category was used instead of the seven-target category because appropriate gamma goat sounds (different from those used in the previous experiments) were not available. Correct identification scores were used to conduct the statistical analysis.

Six-Target Category. The analysis of variance for the number of correct identification scores for the six-target category is presented in Appendix C, Table C-1. No significant differences were found for any of the variables. The nonsignificant bandwidth effect supports the inconclusive results of the earlier exploratory study (Martinek, Pilette, & Biggs, 1978), which suggested that there is no difference between the 50-2000-Hz and 50-4500-Hz conditions. Mean identification completeness was 33% for both bandwidths.

Five-Target Category. The analysis of variance for correct identifications scores is presented in Appendix C, Table C-2. There are no significance effects. The 50-2000-Hz bandwidth resulted in 37% mean identification completeness, while the 50-4500-Hz bandwidth resulted in 36% mean identification completeness.

Two-Target Category. The analysis of variance is presented in Appendix C, Table C-3. Again, there are no significant effects. The 50-2000-Hz bandwidth resulted in 63% mean identification completeness, while the 50-4500-Hz bandwidth resulted in 64% mean identification completeness.

One-Target Category. The analysis of variance is presented in Appendix C, Table C-4. There are no significant effects. The 50-2000-Hz bandwidth resulted in 89% mean identification completeness, and the 50-4500-Hz bandwidth resulted in 90% mean identification completeness.

SUMMARY OF RESULTS AND IMPLICATIONS

Using the continuous sensor concept and 50-2000-Hz bandwidth, the following estimates are given as to what might be expected of trained operators identifying vehicles in convoy at four different S/N ratios.

When the Commander wants a	from trained operators he can expect	with the S/N ratio of
7-target category report: JP, GG, 2-1/2T, 5T, 10T, APC, TNK	23% identification completeness	+6 dB and +12 dB
	28% identification completeness	+18 dB and +24 dB
5-target category report: light-wheeled, medium-wheeled, heavy-wheeled, APC, TNK	28% identification completeness	+6 dB and +12 dB
	32% identification completeness	+18 dB and +24 dB
2-target category report: wheeled, tracked	51% identification completeness	+6 dB
	56% identification completeness	+12 dB
	63% identification completeness	+18 dB and +24 dB
1-target category report: detection	84% identification completeness	+6 dB and +12 dB
	88% identification completeness	+18 dB and +24 dB

Results suggest that in addition to sound quality (pitch, timbre, etc.) operators are using sound intensity (loudness) as a major cue to identify vehicles. An operator's response set is hypothesized in which operators expect heavy vehicles such as 10-ton trucks, tanks, and APCs to sound loud. When they don't because of the attenuating effect of high noise levels, operators tend to identify them as light- and medium-wheeled vehicles (primarily jeeps). This response set produced the surprising outcome that the lighter vehicles were identified correctly with the same (or higher) frequency at decreasing S/N ratios, i.e., increasing noise. With the general category of wheeled vehicles, performance tended to remain the same across the four S/N ratios, i.e., the tendency for light- and medium-wheeled vehicle performance to improve was canceled out by the tendency of heavy-wheeled vehicle performance to deteriorate as S/N ratio decreased. Tracked vehicle identification showed a distinct tendency to deteriorate as S/N ratio decreased.

The value of this program ultimately lies in how the results and implications of the results are utilized. Field commanders, training personnel, and acoustic sensor operators should be made aware of the operator tendency to identify vehicle sounds as light- and medium-wheeled vehicles under high noise conditions. This means that the more transmission relays that are used, the greater the probability that armor and heavy-wheeled vehicles will not be identified as such. Specialized training is recommended both in the school and on the job to counteract this tendency. This training should emphasize the tonal characteristics of the various vehicle sounds, perhaps giving more and varied practice than that used in this research.

For purposes of developing doctrine for the employment of relays and designing new acoustic sensors, a 1% decrease in operator performance can be expected generally, for every 1.5-dB loss in S/N ratio.

An implication of this research is that complete automatic gain control in sensors may actually impair operators' performance. AGC is needed to prevent distortion of the signal, but a reasonable variation of signal strength is necessary, given present-day training.

Finally, the results of this program indicate that the 50-4500-Hz bandwidth offers no performance improvement over the 50-2000-Hz bandwidth that is currently used for Army sensors.

APPENDIX A

TECHNICAL DISCUSSION OF SIGNAL/NOISE RATIO AND TAPING PROCEDURE

One of the physical factors comprising the acoustical signature produced by a vehicle in operation is the amplitude of its emitted sound and the relationship of that sound level to that of the background noise of the environment, i.e., S/N ratio. If the sound pressure level (SPL) of the environmental noise (including noise of the electric system) approaches the SPL of the signal, the latter can be masked partly or completely in the perception of a listener. The unit of measurement of SPLs is the decibel (dB) and is given by:

$$SPL = 20 \log_{10} \frac{\text{given pressure}}{\text{reference pressure}}$$

where reference pressure is that barely detectable by normal, young human hearing and is defined as 20 micro newtons per square meter. Because of the logarithmic measure, a signal of 80 dB and a noise of 50 dB SPL, for example, would be characterized as a +30 dB S/N ratio (80 dB - 50 dB = 30 dB).

In the S/N ratio studies, the differences in the SPLs of the environmental and signal intensities was measured from sounds recorded during an Army field exercise at Fort Hood, Tex. The output of the recorder was low-pass filtered through a GEN RAD Model 1952 filter set to 2000 Hz. The output of the filter was measured by a Ballantine Model 320 true RMS voltmeter with readings on the dB scale. The readings taken for the loudest vehicle (tank) on the entire tape was +4 dB. The reading of ambient noise, i.e., electronic noises, wind, etc. (no vehicles could be heard) was +32 dB. Thus, the best S/N ratio of the recordings was 36 dB.

The four S/N ratios tested (+6 dB, +12 dB, +18 dB, and +24 dB) were selected to span the extremes from a very noisy environment to a relatively quiet environment. In the field, a major source of noise in an acoustic sensor system is the signal transmission system. Each relay can add as much as 4 or 5 dB of noise to the system. Assuming +24 dB S/N ratio to be typical of a normal transmission system, adding four relays can easily bring the S/N ratio down to the noisy condition of +6 dB.

In building the test and training scenarios, S/N ratio was manipulated by playing selected convoys on one tape recorder into a second recorder through a mixing network. The input of the network was fed from a Hewlett-Packard Model 350 attenuator which was fed in turn from the filter (2000 Hz low-pass) which was fed in turn from a Grason-Stadler Model 901B white noise generator. A true RMS voltmeter as well as the second UHER recorder was connected to the output of the mixing network. With the noise generator turned off, the first recorder was played and the reading on the voltmeter was noted for the loudest signal in a convoy. Then with the first recorder turned off, the noise generator was operated and the attenuator set so that the voltmeter gave a reading that was 6 dB, 12 dB, 18 dB, or 24 dB (depending on the S/N ratio required) less than the reading for the loudest signal.

APPENDIX B - FACILITATOR GUIDE

ORIENTATION BRIEFING

Facilitator: Read the following:

I want to welcome everyone here today. We are glad that you could make it and can participate in the exercise we have planned. You will be participating in this exercise a half-day today, a half-day tomorrow, and half of the following day. We think you will find it interesting and worthwhile to your job in the Remote Sensor Platoon. Before going any further I want to introduce myself and my associate and find out who you are.

- Introductions -

I want to take a few minutes now and give you some background concerning this program. Recent requirements in the Army Unattended Ground Sensor (UGS) community have identified a need for human factors studies and training development in the area of sound recognition while monitoring acoustic UGS. The need for studies and training development in sound recognition is desired by UGS field units, the REMBASS program, the United States Army Intelligence Center and School at Ft. Huachuca, and the NATO Project "AVID GUARDIAN" in Europe.

Acoustic sensors are the best confirmation sensors in the Army today, but their full potential has not been realized primarily because of a lack of knowledge on the part of the commander and new system developers concerning what the operator can and cannot do. Much of the information that the commander can use doesn't even exist. That is why we are here--to collect performance data which can be used by the commander and new system developers for doctrine, tactics and systems specification. By participating in this exercise, you, the UGS operator, are helping to answer questions such as:

1. How well can an operator recognize different military vehicles in convoy by listening to the sound that they make?
2. What difference can the amount of background noise make?

3. To what extent can an operator be trained to increase his ability to recognize the sounds of military vehicles in convoy when background noise is present?
4. Does increasing the frequency bandwidth significantly improve sound recognition performance?

The Army is interested in improving surveillance techniques to maximize information output and make the job easier for you. Through its Remotely Monitored Battlefield Surveillance System (REMBASS), the Army is currently planning to include two acoustic sensors in its inventory for the 1980's. These two REMBASS sensors are called the (1) Acoustic Analog Sensor (DT-5XX) and the (2) Seismic/Acoustic Classification Sensor (DT-562).

The Acoustic Analog Sensor is simply an advanced version of the Audio Add-on Unit (AAU) of which you are familiar with. It will drive a speaker/headset for aural analysis by the operator. Because the operator is interpreting, the report is limited only by the operators ability. Operator training plus changes in frequency bandwidth may significantly improve his performance.

The Seismic/Acoustic Classification Sensor will utilize internal logic and digital information processing to automatically classify targets. However, the classification is at a gross level and includes only tracked vehicles, wheeled vehicles and personnel. This sensor will send only a beep every 10 seconds as its output. It will automatically display a T, W, or P on the tac recorder.

During these exercises, your task as a sensor operator will be to listen to tape recordings of military convoys and report what you think you hear. Many of the skills you have acquired in school and on the job will apply. All of you probably have had personal experiences which will apply in that you have heard all of the vehicles at sometime in your life. Today you will hear recorded sounds of Army vehicles which you will report on a simple form called a Target Log. You will be given specific times to ask questions so that the planned exercise will not be interrupted.

It is not the purpose of this exercise to sample all possible vehicles or circumstances involving the use of acoustic sensors but does attempt to sample the sound signatures of certain types of vehicles in a convoy situation using a certain type of sound recording system.

You will hear taped sounds of military vehicle convoys as you would hear them from a modified AAU employed in a field exercise. The aggressor will be traveling in convoys averaging about 10 vehicles (each traveling about 6 seconds apart). One of the problems you will have to deal with is the sound of a loud vehicle partially degrading or masking the sound of a quieter vehicle. Another problem is making a quick decision about a particular vehicle and recording it while still listening to other vehicles within the convoy. You will record your answers using our procedures and forms. Since we know what made the sounds, we can score your report forms for accuracy. We don't expect 100% performance for all targets, but we do expect you to perform as if you were in a combat situation. You must be here for all scheduled times or we won't be able to use your results.

I would like to emphasize that we are not giving you a test to see how good an operator you are. We are here to improve the Army's capability for using the acoustic sensor. All we ask is that you interpret the sounds to the best of your ability and try to make sense out of what sometimes might appear to you to be rather difficult. You are important because you as a group represent the hundreds of UGS operators that have and will be assigned to Remote Sensor Platoons. The use of acoustic sensors in the future will be partially based upon what you can do.

In addition to being relevant to your job in this platoon, there might be another personal advantage for you to do well during this exercise. At various times trained volunteers are requested to serve in various places - some might find attractive, such as at Ft. Chaffee, Ark., or Europe. Of course, there is no guarantee that even if you do well on this exercise you will be assigned the place of your choice, but doing well on this exercise sure wouldn't hurt your chances.

TEST PROCEDURE FAMILIARIZATION

Facilitator: Read the following

This exercise simulates the European theatre in which aggressor convoys are attacking NATO's western boundary. Assume that you are in Germany monitoring a new type of acoustic sensor which is similar to the AAU except that it varies in transmission time. As you know, the AAU "listens" for 15 seconds after being triggered by three seismic activations within a 28-second period. The new acoustic sensor will "listen" continuously for the type of aggressor convoys expected. We will call this sensor the Continuous Sensor.

Your commander has tasked you with the job of monitoring continuous acoustic sensors for vehicle identification purposes. The order of battle (OB) indicates that the aggressor force will be using convoys averaging around 10 vehicles apiece. Speed and traveling intervals of the convoys will affect how you hear each vehicle but the vehicle separation will be around 6 seconds.

Your commander has given you a Target Log which you will use to record vehicle activity. Look at the Target Log that is being passed out now. (Pass out Target Logs). First, fill out the information that is requested along the right-hand margin. Also, put your rank with your name. I'll wait while you do this (about one minute). Notice at the top of the Target Log that your commander is interested in seven vehicles that he knows will be in these convoys. He wants you to place an X in the appropriate column for each vehicle so that he can know how many of each kind in order to determine the threat level. These target types are:

1. Jeeps (shown as JP)
2. Gammo Goats (shown as GG)
3. 2½-ton trucks (shown as 2½T)
4. 5-ton trucks (shown as 5T)
5. 10-ton trucks (shown as 10T)

TARGET LOG

Name ______________________ Date __________

Convoy	VEH	JP	GG	2½T	5T	10T	APC	TNK
Convoy 1	1.							
	2.							
	3.							
	4.							
	5.							
	6.							
	7.							
	8.							
	9.							
	10.							
	11.							
	12.							
Convoy 2	1.							
	2.							
	3.							
	4.							
	5.							
	6.							
	7.							
	8.							
	9.							
	10.							
	11.							
	12.							
Convoy 3	1.							
	2.							
	3.							
	4.							
	5.							
	6.							
	7.							
	8.							
	9.							
	10.							
	11.							
	12.							
Convoy 4	1.							
	2.							
	3.							
	4.							
	5.							
	6.							
	7.							
	8.							
	9.							
	10.							
	11.							
	12.							
Convoy 5	1.							
	2.							
	3.							
	4.							
	5.							
	6.							
	7.							
	8.							
	9.							
	10.							
	11.							
	12.							
Convoy 6	1.							
	2.							
	3.							
	4.							
	5.							
	6.							
	7.							
	8.							
	9.							
	10.							
	11.							
	12.							
	VEH	JP	GG	2½T	5T	10T	APC	TNK

Convoy	VEH	JP	GG	2½T	5T	10T	APC	TNK
Convoy 1	1.							
	2.							
	3.							
	4.							
	5.							
	6.							
	7.							
	8.							
	9.							
	10.							
	11.							
	12.							
Convoy 2	1.							
	2.							
	3.							
	4.							
	5.							
	6.							
	7.							
	8.							
	9.							
	10.							
	11.							
	12.							
Convoy 3	1.							
	2.							
	3.							
	4.							
	5.							
	6.							
	7.							
	8.							
	9.							
	10.							
	11.							
	12.							
Convoy 4	1.							
	2.							
	3.							
	4.							
	5.							
	6.							
	7.							
	8.							
	9.							
	10.							
	11.							
	12.							
Convoy 5	1.							
	2.							
	3.							
	4.							
	5.							
	6.							
	7.							
	8.							
	9.							
	10.							
	11.							
	12.							
Convoy 6	1.							
	2.							
	3.							
	4.							
	5.							
	6.							
	7.							
	8.							
	9.							
	10.							
	11.							
	12.							
	VEH	JP	GG	2½T	5T	10T	APC	TNK

6. Armored personnel carriers (shown as APC)
7. Tanks (shown as TNK). Almost all the tanks are M-60's. If you hear any Sheridan tanks, just list them as tanks along with the M-60.

Notice that there are spaces for 12 convoys on your Target Log with a maximum of 12 vehicles per convoy--six convoys are on the left and six on the right. Are there any questions?

Before we go any further, we want to give you some practice in listening to convoys and recording your answers on the Target Log. You will start on the left-hand side of the Target Log. Notice again that there are six convoys with a maximum of 12 vehicle answer spaces per convoy. A maximum of 12 vehicle answer spaces is given because your commander knows that the aggressor convoys will have anywhere from five to 12 vehicles in each convoy. In this study, six convoys will be equivalent to a Bn level unit.

During this exercise you will be told when a Bn of six convoys is approaching your acoustic sensor. You will also be told when each convoy in the Bn is approaching. This information is what you would normally get from your seismic sensors. The convoys will be traveling at various speeds but your intelligence reports indicate that the time separation between each vehicle will be only 4-10 seconds.

Now, let's run through three convoys to make sure there aren't any misunderstandings and to give you a little practice. These convoys will provide breaks between vehicles so you can get the hand of it. Remember, for each vehicle in the convoy, record your answer with an X. Try to maintain the proper sequence of vehicles throughout the convoy and start on the left side of the Target Log where it says convoy 1. Are there any questions? OK. If the sound is too loud raise your hand. Everybody put your earphones on and lets start.

Facilitator: Play intermittent convoy 1 of training tape 1A (001). As this convoy is playing, check to see that everybody understands the procedure. Stop tape and have a group check.

OK, how did everybody do? Now I will give you the answers for this convoy so you will know what vehicles are involved, then we will replay it.

Convoy 1 Vehicle 1 TNK
Vehicle 2 TNK
Vehicle 3 APC
Vehicle 4 APC
Vehicle 5 APC
Vehicle 6 APC
Vehicle 7 APC
Vehicle 8 APC

Facilitator: Stop tape and have a group check, then replay the convoy.

I think that you now understand how important it is to concentrate on the sounds. Now we will listen to another convoy. Remember to place an X in the right column for your answers. It is important for you to start on the left side of the Target Log where it says convoy 2.

Facilitator: Play intermittent convoy 2 of training tape 1A (005).

OK, how did everybody do? Now I will give you the answers to convoy 2 as before so that you can score yourself, then we will replay it. There is a special task for you to do on your Target Log. As I give you each answer, draw a circle in the proper space with your pencil. Draw a circle for each answer whether you got it right or not. You will need this information for the next step. Remember, draw a circle in the proper space for each answer that I give you whether you got it right or not. For those that you answered correctly, the circle would surround the "X". As the last convoy is replayed, score yourself. Now, I will give you the answers.

Convoy 2 Vehicle 1 JP
Vehicle 2 2½T
Vehicle 3 2½T

Vehicle 4 JP
Vehicle 5 JP
Vehicle 6 10T
Vehicle 7 JP
Vehicle 8 10T

Facilitator: Replay this convoy and have a group check to determine if everybody knows how to score himself.

Now we will listen to another convoy. It is important that you start on the left side of the Target Log where it says convoy 3. Any questions?

Facilitator: Play intermittent convoy 3 of training tape 1A (008.5)

The answers to this convoy in the proper sequence are as follows:

Convoy 3 Vehicle 1 5T
Vehicle 2 5T
Vehicle 3 2½T
Vehicle 4 APC
Vehicle 5 APC
Vehicle 6 5T
Vehicle 7 APC
Vehicle 8 JP
Vehicle 9 5T
Vehicle 10 5T
Vehicle 11 5T

As with the other convoys, you will hear this one again. Follow along as this convoy is replayed.

Facilitator: Replay this convoy. Answer any questions before continuing.

You now know the procedure that you will use to record data. Next you will be given training in which you will have no time breaks between vehicles.

CONVOY SOUND RECOGNITION TRAINING

SECTION A - CONTINUOUS SOUND-NO NOISE CONDITION (50 - 2000 and 50 - 5000 cps)

(015) PART 1 - Vehicle-Pairs Comparisons

Step 1 - Instructions on Tape - You will now participate in a training program designed to increase your ability to recognize the individual vehicles in convoys. In this phase of the training you will be able to compare two sounds of one vehicle type immediately with two sounds of another vehicle type. For example, you will hear two different jeeps, then two different gamma goats. In other words, pairs of vehicle sounds will be given to you. This technique will help you to remember how each target sounds in relation to itself and in relation to other vehicles. As you listen, try to draw from your experience what each vehicle sounds like to you. To some of you, particular vehicles might sound like motorboats, or Honda motorcycles, or Greyhound buses, or perhaps something else. Try to draw a picture in your mind as to what each vehicle sounds like to you to help you remember it longer. Before the vehicles are presented, you will be told which two vehicles are presented first and which two vehicles are presented second. You will not use your Target Log for this exercise. You will now hear the vehicle-pairs comparisons. You will now hear two jeeps followed by two gammo - two jeeps followed by two deuce-and-a-halfs, two jeeps followed by two 5 ton trucks, etc.

Step 2 - Playback - Play vehicle pairs.
(023)

Comparison 1. JP #1 JP #2 followed by GG #1 GG #2
Comparison 2. JP #3 JP #4 followed by 2½T #1 2½T#2
Comparison 3. JP #1 JP #2 followed by 5T #1 5T #2
Comparison 4. JP #3 JP #4 followed by 10T #1 10T #2
Comparison 5. JP #1 JP #2 followed by APC #1 APC #2
Comparison 6. JP #3 JP #4 followed by TNK #1 TNK #2
Comparison 7. GG #3 GG #4 followed by 2½T #3 2½T #4
Comparison 8. GG #1 GG #2 followed by 5T #3 5T #4
Comparison 9. GG #3 GG #4 followed by 10T #3 10T #4
Comparison 10. GG #1 GG #2 followed by APC #3 APC #4
Comparison 11. GG #3 GG #4 followed by TNK #4 TNK #1
Comparison 12. 2½T #1 2½T #2followed by 5T #1 5T #2
Comparison 13. 2½T #3 2½T #4followed by 10T #1 10T #2
Comparison 14. 2½T #1 2½T #2followed by APC #1 APC #2
Comparison 15. 2½T #3 2½T #4followed by TNK #2 TNK #4
Comparison 16. 5T #3 5T #4 followed by 10T #3 10T #4
Comparison 17. 5T #1 5T #2 followed by APC #3 APC #4
Comparison 18. 5T #3 5T #4 followed by TNK #1 TNK #2
Comparison 19. 10T #1 10T #2followed by APC #1 APC #2
Comparison 20. 10T #3 10T #4followed by TNK #4 TNK #1
Comparison 21. APC #3 APC #4followed by TNK #2 TNK #4
Comparison 22. TNK (M60) #2 and TNK (Sheridan) #3

(103) PART 2 - CONTINUOUS SOUND With CPA Feedback

Step 1 - Instructions on Tape - Now you will listen to vehicles in convoy. Aggressor vehicles in convoy are expected to travel close together at about 30 meters to 50 meters apart at speeds of 20-40 kph depending upon road conditions. Let us assume that you are monitoring an acoustic sensor that is commanded to collect continuous sound for such convoys. What this means is that you will only have about 6 seconds on the average to identify any one vehicle within each convoy. Because convoys tend to bunch-up and spread-out, you may have only 4 seconds or up to 8 seconds or more to listen to the sound of any one vehicle. However, you may have more time to identify the first and last vehicle. For example, you may hear the first vehicle in the distance as the sound gets louder and louder so naturally you would have more time to identify the first vehicle. In a similar way, you may have more time to identify the last vehicle as the sound trails off. However, the fact remains that you will not have much time to identify the vehicles within the convoy. Again, you will only have about 6 seconds or less depending upon how much the sound of one vehicle is interfering or masking the sound of another vehicle.

Another point to keep in mind is to use the above information in reverse. That is, since you know that the aggressor vehicles are only about 6 seconds apart, you can conclude that you should be recognizing a different vehicle about every 6 seconds.

You will now hear two convoys. Keep in mind what has just been discussed and see how many vehicles you can detect and recognize. Take your Target Log now and start with the fifth convoy position on the left side. Remember to record your answers with an "X" on your Target Log.

Step 2 - Playback - Play Convoys 5 (117) and 6 (122). Continuous sound condition.
(116.5)

Step 3 - Feedback on Tape - Okay, how did you do? Did everyone get 10 vehicles
(125.5) for convoys 5 and 8 vehicles for convoy 6? Now you will be given the answers to both convoys in the proper sequence. As you are given each answer, draw a circle in the proper space with your pencil. Draw the circle for each answer whether you got it right or not! Do this so you can use this information later. OK? Remember now, draw a circle in the proper space for each answer that I give you whether you got it right or not. If you got one right, then the circle would surround the "X".

Convoy 5 - Target 1 is an APC
(130) Target 2 is an APC
Target 3 is an APC
Target 4 is an APC
Target 5 is an APC
Target 6 is an APC
Target 7 is an APC
Target 8 is an APC
Target 9 is an APC
Target 10 is an APC

Convoy 6- Target 1 is a 2½
(133) Target 2 is a 10T
Target 3 is a 10T
Target 4 is a 2½T
Target 5 is a JP
Target 6 is a JP
Target 7 is a 2½T
Target 8 is a JP

OK, everybody take off his earphones and let's see how well you did.

Facilitator: (136.5) "Stop tape and have a group check" - At this point allow the soldiers to respond to how they performed and reinforce rapport and interest. Make sure everybody recorded the ground truth answers. Answer questions and be responsive to needs of group. When this is finished, say, "OK, everybody put his earphones back on and let's continue."

Step 4 - (137) Instructions for Replay on Tape - Now we will replay both convoys so you can listen to the sounds and compare your answers with the ground truth answers that you just recorded. As these convoys are replayed, you will notice that a short tone will signal when each vehicle is closest to the sensor. This point is called the closest-point-of approach or CPA for short. Now we will replay these Convoys with a tone at each vehicle CPA. Remember to follow your Target Log closely. You don't have to make a report - just follow along and try to learn to recognize each individual vehicle in your mind.

Step 5 - Replay with CPA on Tape - Replay Convoys 5 (141) and 6 (146) with CPA. (150) "Let's listen one more time to these same convoys with the CPA tones. First, however, remove your earphones and let's make sure everybody understands the CPA tone."

(151.75) Facilitator: Stop Tape for Group Check. Explain again the significance of the CPA tone and how it differs from tape recorder clicks between targets in the continuous mode.

Step 6 - (152.5) Re-replay with CPA - Re-replay convoys 5 (152.5) and 6 (157.5) with CPA tone.

(160) Facilitator: Stop tape for group feedback.

(162) SECTION B - BACKGROUND-NOISE TRAINING (50 - 200 cps only)

(1625) PART 1 - Low Background Noise

Step 1 - (163) Instructions on Tape - You will now participate in a training exercise designed to increase your ability to recognize vehicles in convoy when background noise is present. Before listening to convoys, you will hear the sounds of individual vehicles with noise in the background. Each vehicle has its own peculiar sound which is different from the sound of other vehicles. You have already heard vehicle sounds compared with other vehicle sounds when no noise was present. Now you will hear levels of background noise: low noise, medium-low noise, medium-high noise, and high noise. We will deal first with the low background noise condition.

You will now hear a variety of sounds with low background noise. Do not use your Target Log. Just listen and follow along closely. Note the differences and similarities between the sounds of various jeeps, gamma goats, 2½ ton trucks, 5 ton trucks, 10 ton trucks, APC's, and tanks in the low background noise condition.

Step 2 - (172.25) Playback of Vehicle Sounds - Play various vehicles sounds in the low noise condition.

You will now hear jeeps . . . gamma goats . . . , etc.

jeep #1____jeep #2____jeep #3____jeep #4____

(176) goat #1____goat #2____goat #3____goat #4____

(180) 2½ ton #1____2½ ton #2____ 2½ ton #3____2½ ton #4____

(183.5) 5 ton #1____5 ton #2____5 ton #3____5 ton #4____

(188.5) 10 ton #1____10 ton #2____10 ton #3____10 ton #4____

(192.25) APC #1____APC #2____APC #3____APC #4____

(197) tank #1____tank #2____tank #3____tank #4____

Step 3 - Instructions on Tape - Now you will hear two convoys. These convoys will be traveling between 12 to 24 mph which is about the same as 20 to 40 kph. As these convoys are played, see how many vehicles you can detect and identify. Use your Target Log for this exercise and start with convoy 1 on the right side. Okay, is everybody ready? Remember to record your answers with an "X" on your Target Log and start with Convoy 1 on the right side.

Step 4 - (206.5) Playback - Play convoy 1 (206.5) and 2 (212) in the continuous, low noise condition.

Step 5 - (218.75) Self-scoring on Tape - Okay, let's see how well you did. There are 8 vehicles in the first convoy and 9 in the second convoy. Now you will be given the answers to these convoys in the proper sequence so you can score yourself. As you are given each answer, draw a circle in the proper space with your pencil. Draw the circle for each answer whether you got it right or not! Now here are the answers.

Convoy 1 - (222)
Target 1 is a GG
Target 2 is a GG
Target 3 is a JP
Target 4 is a GG
Target 5 is a 2½
Target 6 is a 2½
Target 7 is a 2½
Target 8 is a 2½

Convoy 2 - (225)
Target 1 is a 5T
Target 2 is a TNK
Target 3 is a TNK
Target 4 is a 10T
Target 5 is a JP
Target 6 is a TNK
Target 7 is a JP
Target 8 is a TNK
Target 9 is a APC

Step 6 - (228.5) Instructions for Vehicle Comparisons with Voice Feedback - Now we will replay these same convoys. This time, as you hear the vehicles, you will be told the identity of each vehicle immediately after you hear the sound. Do not use your pencil this time--just follow along on your Target Log. You have already recorded the answers on your Target

Log so it should be easy for you to follow along. We have tried to record only the CPA portion of each vehicle. After the CPA portion of each vehicle plays, you will hear a brief period of silence, then the identity of each vehicle will be given to you. This technique will help you learn where you're making mistakes. Let's try it. Now we will play the convoys with voice feedback.

Step 7 - Replay with Voice Feedback - Play these convoys over in the intermittent, low noise condition with voice feedback.

Convoy 1 - (234)
Convoy 2 - (240)

Step 8 - (248) Instructions - Now you will hear these convoys again without any breaks between the vehicles. This time use your pencils and mark your answers in the convoy 3 and 4 spaces on your Target Log. Put your hand over the convoy 1 and convoy 2 spaces and see how well you can do. Ready?

Step 9 - (250) Replay in Continuous Mode - Replay convoys in the continuous, low noise condition for practice.

(262.5) "This finishes the low background noise condition. Now take your earphones off and let's make sure everybody understands the procedure.

Facilitator: Stop tape and have a group check. Resume when it is clear that everybody understands.

(263.5) PART 2 - Medium-Low Background Noise

Step 1 - (264) Instruction for Vehicle Sounds - You will now hear a variety of vehicle sounds with medium-low background noise. Do not use your Target Log, just listen closely.

Step 2 - (265) Playback of Vehicle Sounds - Play various vehicle sounds with a medium-low noise background.

"You will now hear jeeps . . . gamma goats . . . , etc.

jeep #1________	jeep #2________	jeep #3________	jeep #4________
goat #1________	goat #2________	goat #3________	goat #4________
2½ ton #1________	2½ ton #2________	2½ ton #3________	2½ ton #4________
5 ton #1________	5 ton #2________	5 ton #3________	5 ton #4________
10 ton #1________	10 ton #2________	10 ton #3________	10 ton #4________
APC #1________	APC #2________	APC #3________	APC #4________
tank #1________	tank #2________	tank #3________	tank #4________

Step 3 - (301.5) Instruction for convoys - Now you will hear two convoys with medium-low background noise. These convoys will be traveling between 12 to 24 mph which is about the same as 20 to 40 Kph. As these convoys are played, see how many vehicles you can detect and identify. Remember to record your answers with an "X" on your Target Log and start with Convoy 5 on the right-hand side.

Step 4 - (305) Playback - Play training convoy 5 (305) and 6 (312) in the continuous, medium-low condition.

Step 5 - (317) Self-scoring on Tape - Okay, let's see how well you did. There are 8 vehicles in the fifth convoy and 7 in the sixth convoy. Now you will be given the answers to these convoys in the proper sequence so you can score yourself. Draw a circle in the proper spaces with your pencil whether you got it right or not! Now here are the answers.

Convoy 5 - (320)
Target 1 is a TNK
Target 2 is a TNK
Target 3 is a APC
Target 4 is a JP
Target 5 is a APC
Target 6 is a TNK
Target 7 is a JP
Target 8 is a GG

Convoy 6 - Target 1 is a JP
Target 2 is a JP
Target 3 is a JP
Target 4 is a 2½
Target 5 is a JP
Target 6 is a JP
Target 7 is a 5T

Step 6 - (327) Instructions for Vehicle Comparisons with Voice Feedback - Now we will replay these same convoys. As you hear the vehicles, you will be told the identity of each vehicle immediately after you hear the sound. Do not use your pencil--just follow along on your Target Log. You have already recorded the answers on your Target Log so it should be easy for you to follow along. We have tried to record only the CPA portion of each vehicle. After the CPA portion of each vehicle plays, you will hear a brief period of silence then the identity of each vehicle will be given to you.

Now we will play the convoys with voice feedback.

Step 7 - Replay with Voice Feedback - Play these convoys over in the intermittent, medium-low noise condition with voice feedback.

Convoy 1 - (332.5)
Convoy 2 - (340.5)

Step 8 - (347) Instructions - Now you will hear these convoys again without any breaks between the vehicles. Record your answers on a new Target Log. Take your new Target Log and fill in the right side. I'll wait while you do this.

Facilitator: Stop tape and begin when everyone is ready.

Mark your answers in the convoy 1 and 2 spaces on the left half of your new Target Log. See how many you can do. Ready?

Step 9 - Replay in Continuous Mode - Replay convoys in the continuous, medium-low noise condition for practice.

Convoy 1 - (352)
Convoy 2 - (359.5)

(365) This ends the medium-low background noise training.

<u>Facilitator</u>: Stop tape and have a group check.

(367) PART 3 - Medium-High Background Noise

Step 1 - (370.5) <u>Instructions for Vehicle Sounds</u> - you will now hear a variety of vehicle sounds with medium-high background noise. Do not use your Target Log, just listen closely.

Step 2 - (370.5) <u>Playback of Vehicle Sounds</u> - Play various vehicle sounds with a medium-high noise background.

"You will now hear jeeps . . . gamma goats . . . , etc.

	jeep #1 ________	jeep #2 ________	jeep #3 ________	jeep #4 ________
(375)	goat #1 ________	goat #2 ________	goat #3 ________	goat #4 ________
(381)	2½ ton #1 ________	2½ ton #2 ________	2½ ton #3 ________	2½ ton #4 ________
(387)	5 ton #1 ________	5 ton #2 ________	5 ton #3 ________	5 ton #4 ________
(393)	10 ton #1 ________	10 ton #2 ________	10 ton #3 ________	10 ton #4 ________
(399)	APC #1 ________	APC #2 ________	APC #3 ________	APC #4 ________
(405)	tank #1 ________	tank #2 ________	tank #3 ________	tank #4 ________

Step 3 - (415) <u>Instruction for convoys</u> - Now you will hear two convoys with medium background noise. These convoys will be traveling between 12 to 24 mph which about the same as 20 to 40 Kph. As these convoys are played, see how many vehicles you can detect and identify. Remember to record your answers with an "X" on your Target Log and start with Convoy 3 on the left-hand side.

Step 4 - (419) <u>Playback</u> - Play training convoy 3 (419) and 4 (431) in the continuous, medium-high noise condition.

Step 5 - (439.5) <u>Self-scoring on Tape</u> - Okay, let's see how well you did. There are 10 vehicles in convoy 3 and 10 vehicles in convoy 4. Now you will be given the answers to these convoys in the proper sequence so you can score yourself. As you are given each answer, draw a circle in the proper space with your pencil. Draw the circle for each answer whether you got it right or not! Here are the answers.

Convoy 3 -	Target 1 is an	APC
(444)	Target 2 is an	APC
	Target 3 is an	APC
	Target 4 is an	APC
	Target 5 is an	APC
	Target 6 is an	APC
	Target 7 is an	APC
	Target 8 is an	APC
	Target 9 is an	APC
	Target 10 is an	APC
Convoy 4 -	Target 1 is a	JP
(450.75)	Target 2 is a	2½
	Target 3 is a	2½
	Target 4 is a	JP
	Target 5 is a	JP
	Target 6 is a	10T
	Target 7 is a	JP
	Target 8 is a	10T
	Target 9 is a	2½T
	Target 10 is a	5T

Step 6 - (457.5) Instructions for Vehicle Comparisons with Voice Feedback - Now we will replay these same convoys. This time, as you hear the vehicles, you will be told the identity of each vehicle immediately after you hear the sound. Do not use your pencil this time--just follow along on your Target Log. Now you will play the convoys with voice feedback.

Step 7 - (461.25) Replay with Voice Feedback - Play these convoys over in the intermittent, medium-high noise condition with voice feedback.

Convoy 3 - (461.25)
Convoy 4 - (476)

(485) "This is the end of training tape 1A. Go to training tape 1B."

Step 8 - Replay - Now you will hear these convoys again without any breaks between the vehicles. This time use your pencils and mark your answers in the convoy 5 and convoy 6 spaces on your Target Log. Try not to look at the answers you already have and see how many you can get. Let's go.

Step 9 - Replay in Continuous Mode - Replay convoys in the continuous, medium-high noise condition for practice.

Convoy 5 - (002.5)
Convoy 6 - (008.25)

(012.5) This ends the medium-high background noise training.

Facilitator: Stop tape and have a group check

(014) PART 4 - High Background Noise

Step 1 - (014.25) Instruction for Vehicle Sounds - You will now hear a variety of vehicle sounds with high background noise. Do not use your Target Log, just listen closely.

Step 2 - Playback of Vehicle Sounds - Play various vehicle sounds with a high noise background.

"You will now hear jeeps . . . gamma goats . . . , etc.

	jeep #1________	jeep #2________	jeep #3________	jeep #4________
(017)	goat #1________	goat #2________	goat #3________	goat #4________
(020)	2½ ton #1________	2½ ton #2________	2½ ton #3________	2½ ton #4________
(023)	5 ton #1________	5 ton #2________	5 ton #3________	5 ton #4________
(026.75)	10 ton #1________	10 ton #2________	10 ton #3________	10 ton #4________
(030)	APC #1________	APC #2________	APC #3________	APC #4________
(034.5)	tank #1________	tank #2________	tank #3________	tank #4________

Step 3 - (040) Instruction for convoys - Now you will hear two convoys with high background noise.These convoys will be traveling between 20 and 40 Kph. As these convoys are played, see how many vehicles you can detect and identify. Remember to record your answers with an "X" on your Target Log and start with Convoy 1 on the right-hand side.

Step 4 - (042) <u>Playback</u> - Play training convoy 1 (42) and 2 (47) in the continuous, high noise condition.

Step 5 - (051.5) <u>Self-scoring on Tape</u> - Okay, let's see how well you did. There are 9 vehicles in convoy 1 and 8 vehicles in the second convoy 2. Now you will be given the answers to these convoys in the proper sequence so you can score yourself. As you are given each answer, draw a circle in the proper space with your pencil.

For more practice we will replay these convoys again.

Convoy 1 - (054)
- Target 1 is a 5T
- Target 2 is a TNK
- Target 3 is a TNK
- Target 4 is a 10K
- Target 5 is a JP
- Target 6 is a TNK
- Target 7 is a JP
- Target 8 is a TNK
- Target 9 is a APC

Convoy 2 -
- Target 1 is a GG
- Target 2 is a GG
- Target 3 is a JP
- Target 4 is a GG
- Target 5 is a 2½
- Target 6 is a 2½
- Target 7 is a 2½
- Target 8 is a 2½

Step 6 - (059.25) <u>Instructions for Vehicle Comparisons with Voice Feedback</u> - Now we will replay these same convoys. This time, as you hear the vehicles, you will be <u>told</u> the identity of each vehicle immediately after you hear the sound. Do not use your pencil this time--just follow along on your Target Log. Now we will play the convoys with voice feedback.

Step 7 - <u>Replay with Voice Feedback</u> - Play these convoys over in the intermittent, high noise condition with voice feedback.

Convoy 1 - (061.75)
Convoy 2 - (067)

(072) How did you do? Was everybody able to follow along.

(072.75) Facilitator - Stop tape for group check.

Step 8 - (073) Instructions - Now you will hear these convoys again without any breaks between the vehicles. This time use your pencil and mark your answers in the convoy 3 and 4 spaces on your Target Log. Try not to look at the answers but see how many you can get. This is a difficult noise condition. Let's go!

Step 9 - Replay in Continuous Mode - Replay convoys in the continuous, high noise condition for pratice.

Convoy 3 - (075.5)
Convoy 4 - (080.5)

For more practice we will replay these convoys again.

Step 10 - Instructions - Use your pencil and mark your answers in the convoy 5 and convoy 6 position on your Target Log. *Good Luck!*

Convoy 5 - (087)
Convoy 6 - (092)

Step 11 - Re-replay in the Continuous Mode - This ends the high background noise training.

(097) Facilitator: Stop tape and have a group check.

Part 5 - Continuous Sound - Practice Convoys 1, 2, 3, and 4.

Step 1 - (098) Now let's see what you have learned. We will play four convoys and then you can score yourself. Start with convoy 1 on the right-hand side of the Target Log. Listen closely and see how well you can do.

Step 2 - (178) Play Convoys 1 - Footage 101 (18 dB - mid-low noise)
2 - Footage 105.5 (6" in high noise)
3 - Footage 108 (12" in medium-high noise)
4 - Footage 112 (24" in low noise)

Step 3 - (115) Feedback and Self-Scoring - Facilitator: Read the following. OK, let's see how you did. You will now be given the answers. Draw your circles as I give you the answers.

Convoy 1 - Target 1 is an APC
Target 2 is an APC
Target 3 is an APC
Target 4 is a TNK
Target 5 is a TNK
Target 6 is a TNK
Target 7 is a TNK
Target 8 is a TNK

Convoy 2 - Target 1 is a JP
Target 2 is a 5T
Target 3 is a 5T
Target 4 is a 5T
Target 5 is a 5T

Convoy 3 - Target 1 is an APC
Target 2 is an APC
Target 3 is an APC
Target 4 is a 5T
Target 5 is an TNK
Target 6 is a 2½
Target 7 is a 5T

Convoy 4 - Target 1 is a JP
Target 2 is a 5T
Target 3 is a 5T
Target 4 is a 5T
Target 5 is a 2½

Convoy 4 (Cont.)

Target 6 is a 2½
Target 7 is a 2½
Target 8 is a 5T

(124) Facilitator: Stop tape and have a group check. How many vehicles did you get right? Add them up now and put the total by your name. I'll wait while you do this.

Now, if you left out some vehicles at the beginning of a convoy, that would really mess you up, right? It might make it look like you missed a lot more than you actually did. So, now I want you to score yourself a different way. Add up the total number of vehicles that you got in each category. In other words, add up the total number of jeeps, gammo goats, 2½ ton trucks, etc., and record the totals for each vehicle category at the bottom of your Target Log, I'll wait while you do this.

OK, is everybody ready? Ground truth says that there are 2 JP, 0 GG, 5 2½T, 9 5T, 0 10T, 6 APC, and 6 TNKS. If anyone got a perfect score, who do you think you are trying to kid.

(127) Now for more practice we will play the same convoys again.

Convoy 1 - (227)
Convoy 2 - (132)
Convoy 3 - (134.25)
Convoy 4 - (138.5)

(143) Facilitator: - Stop tape. This is the end of Part 5 and the training exercise.

TARGET LOG

Name ______________________ Date ____________

VEH	JP	GG	2½T	5T	10T	APC	TNK
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APPENDIX C

BANDWIDTH EXPERIMENT

Table C-1

Six-Target Category Analysis of Variance Summary Table

Source of variation	df	Sum of squares	Mean square	F	Sig level
Between subjects	19	890.14			
Groups	1	1.52	1.52	.03	NS
Subject bet/groups	18	888.62	49.37		
Within subjects	60	747.25			
Periods	3	56.84	18.94	1.54	NS
Bandwidth	1	.62	.62	.05	NS
Subject with/groups	56	689.79	12.32		
Total:	79	1,637.39			

Table C-2

Five-Target Category Analysis of Variance Summary Table

Source of variation	df	Sum of squares	Mean square	F	Sig level
Between subjects	19	881.99			
Groups	1	15.42	15.42	.32	NS
Subject bet/groups	18	866.57	48.14		
Within subjects	60	438.50			
Periods	3	40.04	13.35	1.90	NS
Bandwidth	1	4.62	4.62	.65	NS
Subject with/groups	56	393.84	7.03		
Total:	79	1,320.49			

Table C-3

Two-Target Category Analysis of Variance Summary Table

Source of variation	df	Sum of squares	Mean square	F	Sig level
Between subjects	19	1,451.14			
Groups	1	27.62	27.62	.35	NS
Subject bet/groups	18	1,423.52	79.08		
Within subjects	60	975.75			
Periods	3	35.24	11.75	.70	NS
Bandwidth	1	4.52	4.52	.27	NS
Subject with/groups	56	935.99	16.71		
Total:	79	2,426.89			

Table C-4

One-Target Category Analysis of Variance Summary Table

Source of variation	df	Sum of squares	Mean square	F	Sig level
Between subjects	19	873.74			
Groups	1	73.69	73.69	1.66	NS
Subject bet/groups	18	800.05	44.45		
Within subjects	60	428.74			
Periods	3	39.64	13.21	2.00	NS
Bandwidth	1	6.61	6.61	<1	NS
Subject with/groups	56	382.49	6.83		
Total:	79	1,302.48			

DISTRIBUTION

ARI Distribution List

4 OASD (M&RA)
2 HQDA (DAMI-CSZ)
1 HQDA (DAPE-PBR)
1 HQDA (DAMA-AR)
1 HQDA (DAPE-HRE-PO)
1 HQDA (SGRD-ID)
1 HQDA (DAMI-DOT-C)
1 HQDA (DAPC-PMZ-A)
1 HQDA (DACH-PPZ-A)
1 HQDA (DAPE-HRE)
1 HQDA (DAPE-MPO-C)
1 HQDA (DAPE-DW)
1 HQDA (DAPE-HRL)
1 HQDA (DAPE-CPS)
1 HQDA (DAFD-MFA)
1 HQDA (DARD-ARS-P)
1 HQDA (DAPC-PAS-A)
1 HQDA (DUSA-OR)
1 HQDA (DAMO-RQR)
1 HQDA (DASG)
1 HQDA (DA10-PI)
1 Chief, Consult Div (DA-OTSG), Adelphi, MD
1 Mil Asst. Hum Res, ODDR&E, OAD (E&LS)
1 HQ USARAL, APO Seattle, ATTN: ARAGP-R
1 HQ First Army, ATTN: AFKA-OI-TI
2 HQ Fifth Army, Ft Sam Houston
1 Dir, Army Stf Studies Ofc, ATTN: OAVCSA (DSP)
1 Ofc Chief of Stf, Studies Ofc
1 DCSPER, ATTN: CPS/OCP
1 The Army Lib, Pentagon, ATTN: RSB Chief
1 The Army Lib, Pentagon, ATTN: ANRAL
1 Ofc, Asst Sect of the Army (R&D)
1 Tech Support Ofc, OJCS
1 USASA, Arlington, ATTN: IARD-T
1 USA Rsch Ofc, Durham, ATTN: Life Sciences Dir
2 USARIEM, Natick, ATTN: SGRD-UE-CA
1 USATTC, Ft Clayton, ATTN: STETC-MO-A
1 USAIMA, Ft Bragg, ATTN: ATSU-CTD-OM
1 USAIMA, Ft Bragg, ATTN: Marquat Lib
1 US WAC Ctr & Sch, Ft McClellan, ATTN: Lib
1 US WAC Ctr & Sch, Ft McClellan, ATTN: Tng Dir
1 USA Quartermaster Sch, Ft Lee, ATTN: ATSM-TE
1 Intelligence Material Dev Ofc, EWL, Ft Holabird
1 USA SE Signal Sch, Ft Gordon, ATTN: ATSO-EA
1 USA Chaplain Ctr & Sch, Ft Hamilton, ATTN: ATSC-TE-RD
1 USATSCH, Ft Eustis, ATTN: Educ Advisor
1 USA War College, Carlisle Barracks, ATTN: Lib
2 WRAIR, Neuropsychiatry Div
1 DLI, SDA, Monterey
1 USA Concept Anal Agcy, Bethesda, ATTN: MOCA-MR
1 USA Concept Anal Agcy, Bethesda, ATTN: MOCA-JF
1 USA Arctic Test Ctr, APO Seattle, ATTN: STEAC-PL-MI
1 USA Arctic Test Ctr, APO Seattle, ATTN: AMSTE-PL-TS
1 USA Armament Cmd, Redstone Arsenal, ATTN: ATSK-TEM
1 USA Armament Cmd, Rock Island, ATTN: AMSAR-TDC
1 FAA-NAFEC, Atlantic City, ATTN: Library
1 FAA-NAFEC, Atlantic City, ATTN: Human Engr Br
1 FAA Aeronautical Ctr, Oklahoma City, ATTN: AAC-44D
2 USA Fld Arty Sch, Ft Sill, ATTN: Library
1 USA Armor Sch, Ft Knox, ATTN: Library
1 USA Armor Sch, Ft Knox, ATTN: ATSB-DI-E
1 USA Armor Sch, Ft Knox, ATTN: ATSB-DT-TP
1 USA Armor Sch, Ft Knox, ATTN: ATSB-CD-AD
2 HQUSACDEC, Ft Ord, ATTN: Library
1 HQUSACDEC, Ft Ord, ATTN: ATEC-EX-E -Hum Factors
2 USAEEC, Ft Benjamin Harrison, ATTN: Library
1 USAPACDC, Ft Benjamin Harrison, ATTN: ATCP-HR
1 USA Comm-Elect Sch, Ft Monmouth, ATTN: ATSN-EA
1 USAEC, Ft Monmouth, ATTN: AMSEL-CT-HDP
1 USAEC, Ft Monmouth, ATTN: AMSEL-PA-P
1 USAEC, Ft Monmouth, ATTN: AMSEL-SI-CB
1 USAEC, Ft Monmouth, ATTN: C, Facl Dev Br
1 USA Materials Sys Anal Agcy, Aberdeen, ATTN: AMXSY-P
1 Edgewood Arsenal, Aberdeen, ATTN: SAREA-BL-H
1 USA Ord Ctr & Sch, Aberdeen, ATTN: ATSL-TEM-C
2 USA Hum Engr Lab, Aberdeen, ATTN: Library/Dir
1 USA Combat Arms Tng Bd, Ft Benning, ATTN: Ad Supervisor
1 USA Infantry Hum Rsch Unit, Ft Benning, ATTN: Chief
1 USA Infantry Bd, Ft Benning, ATTN: STEBC-TE-T
1 USASMA, Ft Bliss, ATTN: ATSS-LRC
1 USA Air Def Sch, Ft Bliss, ATTN: ATSA CTD ME
1 USA Air Def Sch, Ft Bliss, ATTN: Tech Lib
1 USA Air Def Bd, Ft Bliss, ATTN: FILES
1 USA Air Def Bd, Ft Bliss, ATTN: STEBD-PO
1 USA Cmd & General Stf College, Ft Leavenworth, ATTN: Lib
1 USA Cmd & General Stf College, Ft Leavenworth, ATTN: ATSW-SE-L
1 USA Cmd & General Stf College, Ft Leavenworth, ATTN: Ed Advisor
1 USA Combined Arms Cmbt Dev Act, Ft Leavenworth, ATTN: DepCdr
1 USA Combined Arms Cmbt Dev Act, Ft Leavenworth, ATTN: CCS
1 USA Combined Arms Cmbt Dev Act, Ft Leavenworth, ATTN: ATCASA
1 USA Combined Arms Cmbt Dev Act, Ft Leavenworth, ATTN: ATCACO-E
1 USA Combined Arms Cmbt Dev Act, Ft Leavenworth, ATTN: ATCACC-CI
1 USAECOM, Night Vision Lab, Ft Belvoir, ATTN: AMSEL-NV-SD
3 USA Computer Sys Cmd, Ft Belvoir, ATTN: Tech Library
1 USAMERDC, Ft Belvoir, ATTN: STSFB-DQ
1 USA Eng Sch, Ft Belvoir, ATTN: Library
1 USA Topographic Lab, Ft Belvoir, ATTN: ETL-TD-S
1 USA Topographic Lab, Ft Belvoir, ATTN: STINFO Center
1 USA Topographic Lab, Ft Belvoir, ATTN: ETL-GSL
1 USA Intelligence Ctr & Sch, Ft Huachuca, ATTN: CTD-MS
1 USA Intelligence Ctr & Sch, Ft Huachuca, ATTN: ATS-CTD-MS
1 USA Intelligence Ctr & Sch, Ft Huachuca, ATTN: ATSI-TE
1 USA Intelligence Ctr & Sch, Ft Huachuca, ATTN: ATSI-TEX-GS
1 USA Intelligence Ctr & Sch, Ft Huachuca, ATTN: ATSI-CTS-OR
1 USA Intelligence Ctr & Sch, Ft Huachuca, ATTN: ATSI-CTD-DT
1 USA Intelligence Ctr & Sch, Ft Huachuca, ATTN: ATSI-CTD-CS
1 USA Intelligence Ctr & Sch, Ft Huachuca, ATTN: DAS/SRD
1 USA Intelligence Ctr & Sch, Ft Huachuca, ATTN: ATSI-TEM
1 USA Intelligence Ctr & Sch, Ft Huachuca, ATTN: Library
1 CDR, HQ Ft Huachuca, ATTN: Tech Ref Div
2 CDR, USA Electronic Prvg Grd, ATTN: STEEP-MT-S
1 HQ, TCATA, ATTN: Tech Library
1 HQ, TCATA, ATTN: AT CAT-OP-Q, Ft Hood
1 USA Recruiting Cmd, Ft Sheridan, ATTN: USARCPM-P
1 Senior Army Adv., USAFAGOD/TAC, Elgin AF Aux Fld No. 9
1 HQ, USARPAC, DCSPER, APO SF 96558, ATTN: GPPE-SE
1 Stimson Lib, Academy of Health Sciences, Ft Sam Houston
1 Marine Corps Inst., ATTN: Dean-MCI
1 HQ, USMC, Commandant, ATTN: Code MTMT
1 HQ, USMC, Commandant, ATTN: Code MPI-20-28
2 USCG Academy, New London, ATTN: Admission
2 USCG Academy, New London, ATTN: Library
1 USCG Training Ctr, NY, ATTN: CO
1 USCG Training Ctr, NY, ATTN: Educ Svc Ofc
1 USCG, Psychol Res Br, DC, ATTN: GP 1/62
1 HQ Mid-Range Br, MC Det, Quantico, ATTN: P&S Div

1 US Marine Corps Liaison Ofc, AMC, Alexandria, ATTN: AMCGS-F
1 USATRADOC, Ft Monroe, ATTN: ATRO-ED
6 USATRADOC, Ft Monroe, ATTN: ATPR-AD
1 USATRADOC, Ft Monroe, ATTN: ATTS-EA
1 USA Forces Cmd, Ft McPherson, ATTN: Library
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1 USA Agcy for Aviation Safety, Ft Rucker, ATTN: Library
1 USA Agcy for Aviation Safety, Ft Rucker, ATTN: Educ Advisor
1 USA Aviation Sch, Ft Rucker, ATTN: PO Drawer O
1 HQUSA Aviation Sys Cmd, St Louis, ATTN: AMSAV-ZDR
2 USA Aviation Sys Test Act., Edwards AFB, ATTN: SAVTE-T
1 USA Air Def Sch, Ft Bliss, ATTN: ATSA TEM
1 USA Air Mobility Rsch & Dev Lab, Moffett Fld, ATTN: SAVDL-AS
1 USA Aviation Sch, Res Tng Mgt, Ft Rucker, ATTN: ATST-T-RTM
1 USA Aviation Sch, CO, Ft Rucker, ATTN: ATST-D-A
1 HQ, DARCOM, Alexandria, ATTN: AMXCD-TL
1 HQ, DARCOM, Alexandria, ATTN: CDR
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1 US Military Academy, West Point, ATTN: Ofc of Milt Ldrshp
1 US Military Academy, West Point, ATTN: MAOR
1 USA Standardization Gp, UK, FPO NY, ATTN: MASE-GC
1 Ofc of Naval Rsch, Arlington, ATTN: Code 452
3 Ofc of Naval Rsch, Arlington, ATTN: Code 458
1 Ofc of Naval Rsch, Arlington, ATTN: Code 450
1 Ofc of Naval Rsch, Arlington, ATTN: Code 441
1 Naval Aerospc Med Res Lab, Pensacola, ATTN: Acous Sch Div
1 Naval Aerospc Med Res Lab, Pensacola, ATTN: Code L51
1 Naval Aerospc Med Res Lab, Pensacola, ATTN: Code L5
1 Chief of NavPers, ATTN: Pers-OR
1 NAVAIRSTA, Norfolk, ATTN: Safety Ctr
1 Nav Oceanographic, DC, ATTN: Code 6251, Charts & Tech
1 Center of Naval Anal, ATTN: Doc Ctr
1 NavAirSysCom, ATTN: AIR-5313C
1 Nav BuMed, ATTN: 713
1 NavHelicopterSubSqua 2, FPO SF 96601
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1 AFHRL (TT) Lowry AFB
1 AFHRL (AS) WPAFB, OH
2 AFHRL (DOJZ) Brooks AFB
1 AFHRL (DOJN) Lackland AFB
1 HQUSAF (INYSD)
1 HQUSAF (DPXXA)
1 AFVTG (RD) Randolph AFB
3 AMRL (HE) WPAFB, OH
2 AF Inst of Tech, WPAFB, OH, ATTN: ENE/SL
1 ATC (XPTD) Randolph AFB
1 USAF AeroMed Lib, Brooks AFB (SUL-4), ATTN: DOC SEC
1 AFOSR (NL), Arlington
1 AF Log Cmd, McClellan AFB, ATTN: ALC/DPCRB
1 Air Force Academy, CO, ATTN: Dept of Bel Scn
5 NavPers & Dev Ctr, San Diego
2 Navy Med Neuropsychiatric Rsch Unit, San Diego
1 Nav Electronic Lab, San Diego, ATTN: Res Lab
1 Nav TrngCen, San Diego, ATTN: Code 9000-Lib
1 NavPostGraSch, Monterey, ATTN: Code 55Aa
1 NavPostGraSch, Monterey, ATTN: Code 2124
1 NavTrngEquipCtr, Orlando, ATTN: Tech Lib
1 US Dept of Labor, DC, ATTN: Manpower Admin
1 US Dept of Justice, DC, ATTN: Drug Enforce Admin
1 Nat Bur of Standards, DC, ATTN: Computer Info Section
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1 Scientific Advsr, Mil Bd, Army Hq, Russell Ofcs, Canberra
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1 Centre de Recherche Des Facteurs, Humaine de la Defense Nationale, Brussels
2 Canadian Joint Staff Washington
1 C/Air Staff, Royal Canadian AF, ATTN: Pers Std Anal Br
3 Chief, Canadian Def Rsch Staff, ATTN: C/CRDS(W)
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1 Def & Civil Inst of Enviro Medicine, Canada
1 AIR CRESS, Kensington, ATTN: Info Sys Br
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1 Military Attache, French Embassy, ATTN: Doc Sec
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1 Pers Rsch Ofc Library, AKA, Israel Defense Forces
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