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Technical Research Report 1175

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EFFECTS OF STANO SENSORS ON SMALL UNIT EFFECTIVENESS--PART II

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February 1972

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BEHAVIOR AND SYSTEMS RESEARCH LABORATORY

An activity of the Chief, Research and Development

J. E. UHLANER
Director

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BEHAVIOR AND SYSTEMS RESEARCH LABORATORY

Office, Chief of Research and Development
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FOREWORD

The STANO Performance Optimization Program (formerly Night Operations) within the Behavior and Systems Research Laboratory is concerned with problems in optimizing human performance in relation to night vision devices and related sensors. Specific aspects deal with determining performance effectiveness of sensor systems, factors which affect performance, and means of improving effectiveness. The entire research program is responsive to requirements of the Combat Developments Command and is conducted under RDT&E Project 2Q062106A723, Human Performance in Military Systems, FY 1971 Work Program.

This program is being executed by the BESRL Field Experimentation Unit at Fort Ord, California, in conjunction with and with the support of the Combat Developments Experimentation Command (CDEC). Personnel of the Behavior and Systems Research Laboratory are deeply appreciative of the excellent cooperation given the research program by CDEC in providing technical, personnel, and materiel support. Special acknowledgement is made of the efforts of the Commanding General, Brigadier General E. R. Ochs, and of Project Team III, which, under the command of Colonel J. Fulton, directly supported the research activity.

The present experiment is designed to provide comparative performance data on the effectiveness of small units utilizing six different mixes of STANO sensors. The present publication reports on Part II of the experiment covering evaluation of selected mixes of STANO sensors, and has been prepared to meet the need of various Army agencies and other users for immediate knowledge of results. An earlier publication (Technical Research Note 237) reported the findings in Part I. A final report will provide integrated analysis and conclusions based on all data.

BESRL research in night operations is conducted as an in-house research effort augmented by research contracts with organizations selected as having unique capabilities for research in this area. The present experiment was conducted under the program direction of Jack J. Sternberg, Behavior and Systems Research Laboratory, assisted by personnel of Manned Systems Sciences, Northridge, California, under the supervision of Douglass R. Nicklas.

J. E. UHLANER, Director
Behavior and Systems
Research Laboratory

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EFFECTS OF STANO SENSORS ON SMALL UNIT EFFECTIVENESS--PART II

BRIEF

Requirement:

To determine, taking into account human factor variables, how STANO sensors affect small unit effectiveness and which mixes of sensors provide the most effective continuous operations capability.

Procedures:

The experiment was divided into two parts. In Part I, previously reported, squads used three mixes of STANO sensors under two sensor deployment conditions in a linear defense situation. In Part II, three additional mixes were tested under the same conditions.

Squads equipped with various mixes of STANO sensors were told that they were occupying a position in a linear defense and that it was their job to detect, describe, and report to their squad leader any enemy activity in their area of responsibility. The squad leader had freedom, but limited, to interact with his squad members. He also had the option of reporting to his platoon leader all, part of, or none of the information received from the squad members. Sensors used by the players were the Starlight Scope (SS), the Hand Held Thermal Viewer (HHTV), the Patrol Seismic Intrusion Device (PSID), and the PPS-14 Radar (PPS-14). The terrain extended to 350 meters and was heterogeneous, being flat to hilly and including some open areas and some heavily cluttered areas. Personnel targets--one man, three men, or six men--moved through the squad area of responsibility along specified paths.

A counterbalanced design was used so that each squad had an opportunity to find the same targets using each of the mixes from each of the observer positions. Testing for Part II of the experiment, reported here, was conducted under starlight and full-moon illumination conditions. Eighteen squads (twelve under starlight and six under moonlight conditions) were tested on each of three mixes (with three sensors per mix) for two tactical deployments of the sensors. Under starlight, a total of 144 targets were presented for each mix, 72 in each sensor deployment condition; under moonlight, 72 targets were presented for each mix, 36 in each deployment condition.

Findings:

When two-sensor mixes were used, difference in percent detections among the mixes was not significant. Addition of a third sensor did not increase the squad's detection capability. However, when other measures of effectiveness were considered, such as quality of target information, there was a difference between the two- and three-sensor mixes and also a difference due to the types of sensor in the mixes. Of the two-sensor mixes, the SS/PSID mix was superior. Of the three-sensor mixes, the mix with one SS, one HHTV, and one PSID was superior.

Under high illumination, there was improvement in quality of performance for mixes containing a SS. The best mix under high illumination was the same as the best mix under low illumination.

The number of false reports was small for all sensors and mixes, but was higher for the HHTV than for the other sensors.

Information obtained by a sensor operator was reported without meaningful loss to the squad leader, but substantial degradation in quality of information occurred in transmission of information from squad leader to platoon leader.

Utilization:

Empirical results are useful in deciding how the infantry squad should be equipped with STANO sensors, when quantity, quality, and timeliness are important aspects of performance. Results are also useful in gaming and modeling. Finally, while there are differences between sensors and mixes of sensors, the principal loss in target information is due to faulty control and communication at the squad-platoon level. Results strongly suggest the need for improved procedures or more adequate training, or both.

CONTENTS

TABLES

BACKGROUND

A large number of sensors have been developed for the purpose of enhancing the Army's night operations capabilities. Military management decisions must be made as to which sensors should be selected and how they should be used. Previous testing and evaluation of these sensors has dealt with them primarily as issues of individual equipment. Emphasis has been on their capabilities for detecting targets. The question of the timeliness and quality of the target information they provide has largely been neglected. Thus, there is serious lack of experimental data on the effectiveness of the sensors--considering timeliness and quality as well as detection--when they are used in combination, that is, on how the various sensors complement and supplement each other to provide more complete and timely target information.

To provide military management with such information, a field experiment was designed to determine how different mixes of selected STANO sensors differentially affect small unit performance. Specific objectives of the research are:

1. To determine, considering human factors variables, how the rifle squad should be equipped with STANO sensors to provide the most effective continuous operations capability.

2. To determine the timeliness, accuracy, and content of target information that operators employing various STANO sensors can be expected to report.

3. To determine how performance can be improved by new search techniques, work methods and team procedures, deployment conditions, and command and control and communication techniques.

The entire experiment dealt with the effectiveness of the squad-sized unit equipped with various mixes of STANO sensors for a linear defense situation in which a squad is assigned to maintain a position in an area defense. The four STANO sensors employed were the Starlight Scope (SS), the PPS-14 Radar (PPS-14), the Patrol Seismic Intrusion Device (PSID), and the Hand-Held Thermal Viewer (HHTV). Six mixes consisting of three sensors per mix were empirically tested. The effectiveness of other mixes and of individual sensors was analytically determined.

Because of the equipment available and the necessary ambient light conditions, the experiment was divided into two parts. The present publication describes some findings of Part II, in which three mixes were empirically tested and others analytically evaluated. An earlier interim report described the findings in Part I in which other other mixes were tested. A final report will provide an integrated analysis and conclusions based upon all data.

METHOD

The research method employed in Part II of the experiment is described briefly here.

Critical Factors

Sensors:

1. Starlight Scope, AN/PVS-2 (SS)
2. Listening Post Surveillance Device, AN/PPS-14 (PPS-14)
3. Patrol Seismic Intrusion Device, AN/GSQ-151 (PSID)
4. Hand-Held Thermal Viewer, AN/PAS-7 (HHTV)

Equipment Mixes Empirically Tested

1. Two Starlight Scopes and one Thermal Viewer.
2. One Starlight Scope, one PPS-14 Radar, and one Thermal Viewer.
3. One Starlight Scope, one PSID, and one Thermal Viewer.

Equipment Mixes Analytically Tested

1. Two Starlight Scopes
2. One Starlight Scope and one Thermal Viewer
3. One Starlight Scope and one PSID.
4. One Starlight Scope and PPS-14.
5. One PSID and one Thermal Viewer
6. One PPS-14 and one Thermal Viewer.

Sensor Deployment. The PSID geophones and the PPS-14 radar locations were selected to provide the largest area of coverage without duplication of coverage in specific terrain areas. The locations of these sensors were established without knowledge of the target paths, in order to avoid possible bias for or against certain sensors or mixes. As deployment could easily be an important factor influencing mix effectiveness, two different sensor deployments, FAR and NEAR, were used. In the first, the PSID geophones were emplaced across the squad front at a range of 225-250 meters from the squad line (PSID FAR condition), and the PPS-14 radar was remoted to a central point 35 meters in front of the squad line and mounted to provide an antenna height of six feet (PPS-14 NEAR condition). In the second sensor deployment, the terrain relationship of the two sensors was reversed, the PSID geophones being emplaced at a range of 125-150 meters from the squad line (PSID NEAR condition) and the PPS-14 radar being remoted to a central point 175 meters in front of the squad line (PPS-14 FAR condition). For both deployment conditions, the SS's and the receivers for the remoted sensors were placed in the booths on the squad line. This placement of the sensors permitted comparisons involving the sensors when both were deployed FAR, when both were deployed NEAR, and when one was NEAR and the other FAR.

Subjects

The subjects, or players, were enlisted men with an infantry MOS. Twelve squads were tested under starlight and six under moonlight illumination conditions. Each squad was tested three nights.

Instrumentation

A general description of the data acquisition system used has been given in another publication [1]. Essential elements were the tripods on which universal device platforms (UDP's) were mounted, the data recording and monitoring systems, and electro-mechanical counters. As the SS's and HHTV's were mounted on the UDP's, it was possible to determine the orientation (azimuth and elevation) of these devices with an accuracy of 0.1°. This information was electronically recorded four times per second on magnetic tape. At each operator position there were also a response button and an electro-mechanical counter. Each time the button was pressed, the response was automatically recorded on magnetic tape, along with the number of that response. The same number was also displayed on the counter at the player position and was entered by the player on a report form, along with his description of the target. As the same number was recorded on the magnetic tape and the report form, the two measures could easily be combined during subsequent data analysis.

Terrain and Player Positions

The terrain was heterogeneous, being flat to hilly with some open and some heavily cluttered areas. It extended to 350 meters and was trapezoidal in shape, with a width of approximately 60 meters at the squad line and approximately 400 meters at the far limit.

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[1] Jack J. Sternberg, and James H. Banks. Search effectiveness with passive night vision devices. BESRL Technical Research Report 1163. June 1970.

Nine booths placed on-line provided for three squad positions of three player positions each. The separation of the right and left flank booths for a single squad position was 33 meters. The squad leader was always positioned in the center of his squad. As viewing angle differed somewhat for the three squad positions, squads were rotated to all positions during testing.

Sensor Deployment and Targets

One of the most difficult problems in experimentation in this area is the placement of sensors and targets to avoid introducing bias of sensor effectiveness. To this end, a strategy was devised by which sensors were laid out without knowledge of target paths and target paths were determined without knowledge of sensor locations. The sensors were tactically deployed so as to cover the largest area possible rather than likely avenues of approach.

The targets were personnel--one man or groups of three men or six men. All targets were dynamic and moved in an upright position on specified target paths in the area of squad responsibility. Twenty-four paths were randomly selected to provide points of entry across the full front and sides of the search area, as well as multiple lines of approach within the search area. Six paths entered the search area from the right and left flanks, crossing the squad front and exiting on the other side; eighteen paths entered the search area from the far side and end of the squad area of responsibility, approaching to within 50 meters of the squad front. Targets walked at a speed of about one meter per second, resulting in a target exposure time of about five minutes for each path.

Illumination Conditions

Testing was conducted under starlight and three-quarter to full-moon illumination. Under starlight, mean nightly readings ranged from 8.6×10^{-5} to 1.6×10^{-4} footcandles. Mean illumination for all starlight nights of testing was 1.1×10^{-4} footcandles. Under moonlight, mean nightly readings ranged from 5.1×10^{-3} to 1.1×10^{-2} footcandles. Mean illumination for all moonlight nights of testing was 7.8×10^{-3} footcandles.

Procedures

Squad Procedures. Prior to testing, all players were thoroughly trained on use of the sensors and on experimental procedures. They were told that they were working as members of an infantry squad occupying a position in an area defense. They had previously overrun and cleared the area in front of their position and had emplaced intrusion detectors.

They had then withdrawn and taken up their present position, which they would be occupying during the night. It was their responsibility to detect, describe, and report any enemy personnel who might move into their area during the night.

A squad position was composed of three booths. Each booth was equipped with a sensor and was occupied by two men. In the booths occupied by squad members, one player acted as sensor operator and one as data collector/runner who recorded target acquisition information on a report form (see Appendix for sample report forms) and reported the information to the squad leader. In the center booth were two players (the squad leader and a sensor operator) and a controller. When a runner came to the squad leader's booth, he brought the report form on which the observer's report was filled out. After giving this form to the controller, the runner made a verbal report to the squad leader. The squad leader then exercised one or more of his options for action. The controller recorded on the report form the content of the runner's verbal report (for later verification of accuracy) as well as the actions of the squad leader.

The squad leader had three basic actions he could take:

1. If the report came from an observer with a SS or HHTV, he was required to direct the original observer either to continue to observe the same target or to break contact with that target to search for other targets. (This direction was for the SS and HHTV only, as operators with other sensors were not able to break contact with the target at will.)

2. Regardless of which sensor produced the original report, the squad leader could, if he wished, send the runner to another booth which contained a SS to report the target information to the device operator and request confirmation and added information on distance and size.

3. For any report, the squad leader had the option of reporting or not reporting the information to his platoon leader. For example, if the squad leader received a report from a PPS-14 operator, he could delay making a report to his platoon leader while he attempted to get confirmation and additional information from one of his operators with a SS. The controller recorded the squad leader's action on the report form and, if the squad leader chose to report to the platoon leader, the content of his report.

One night's testing consisted of 36 search periods, 18 on the first sensor deployment condition (PSID-FAR, PPS-14 NEAR) and 18 on the second PSID-NEAR, PPS-14 FAR). Search periods varied in length from five to nine minutes. In order to prevent players from anticipating target behavior, several procedures were used:

1. No targets were presented in one-third (12) of the search periods.

2. For search periods during which targets were presented, no systematic pattern of target "start" position was used, and the time of target presentation after the beginning of a search period was varied.

3. Although the same target were presented in both sensor deployment conditions (in order to permit direct comparison of the two deployments), the order of target presentation was varied.

Three squads were tested simultaneously, each squad using one of the equipment mixes. These three squads alternated with another three squads after every three search periods. The mixes used by the squads were changed after every six search periods. Thus, six squads were tested each night with each squad using all three mixes on both sensor deployment conditions.

All squads were tested for three nights. The position occupied by each squad and the specific targets presented to each squad were varied across nights. Under starlight, 144 targets in all were presented to each mix, 72 in each sensor deployment condition; under moonlight, 72 targets were presented to each mix, 36 in each deployment condition.

Target Control and Scoring Procedures. Target location and target control were obtained by two target monitors located in booths at each end of the line of player booths. Each target monitor was equipped with a Night Observation Device, Medium Range (NOD), mounted on a universal device platform. The monitor constantly tracked the target, keeping the reticle of the NOD on the center of mass of the target as it moved along its prescribed path. The azimuth and elevation from the two trackers were displayed on NIXIE tubes in the instrumentation trailer. In order to insure that the targets moved along the specified path at the correct speed, the NIXIE tube display was constantly monitored. Target location was checked against a target path map showing azimuth, elevation, and time coordinates for each target path. If the target deviated from the correct path, or moved at the wrong speed, the deviation could be immediately determined by comparing tracker device orientation with the map coordinates and then corrected by radio communication with the target.

Azimuth and elevation of the two trackers were electronically recorded. As the distance separating the two trackers was known, as well as the angle from each tracker to the target, it was possible to determine at all times the exact target location. A target acquisition response by one of the players with a SS was scored as a "hit" if the azimuth of his device was within plus or minus 5° of the actual target location.

When a target was in a PSID or PPS-14 area, its presence was recorded on the magnetic tape of the data acquisition system. A target acquisition response by a player with one of these sensors was scored as a "hit" only when the player's response occurred within the same period as marked on the tape.

RESULTS

Data were analyzed in terms of 1) observer reports, 2) reports to squad leader, and 3) reports to platoon leader. In this way, it was possible to determine the efficacy of the mixes as well as any control and communication problems which might arise at critical points in the transmission sequence.

Data are presented so as to show the effects of mix and of sensor deployment. Comparisons were made for individual sensors, mixes involving two sensors, and mixes involving three sensors. The mixes of three sensors were empirically tested. The results on individual sensors and two-sensor mixes were obtained by analytic treatment of the data. The results are shown for two sensor deployment conditions and for two illumination conditions.

The measures of effectiveness used are the percentage of targets detected and the quality and timeliness of detection. Quality is defined as the percentage of targets detected with accurate descriptions of target size and distance. To be scored as correct on size, a one-man target had to be reported as one man, a three-man target had to be reported as two or three or four men, and a six-man target as five or six or seven men. To be scored as correct on distance, a target at 200-300 meters had to be reported within plus or minus 30 meters of its true distance; at 100-199 meters, within plus or minus 20 meters of its true distance, and at 50-99 meters, within plus or minus 10 meters of its true distance. Under timeliness, the data are presented in terms of target detections and quality in three criterion zones: Zone 1 = 200-300 meters; Zone 2 = 100-300 meters; Zone 3 = 50-300 meters. Note that the criterion zones overlap; Zone 2 includes the area defined as Zone 1, and Zone 3 encompasses the entire search area. Thus, target detections are cumulative, the results shown in Zone 3 being the maximum detections and quality obtained.

For clarity of presentation, percentage detections and quality are shown first for Zone 3 under starlight illumination with the data combined from the two deployment conditions. The results are then progressively broken out to show the effects of criterion zone, deployment, and illumination where these are factors.

Observer Report

Percent Detection. The overall percentages of targets detected by single sensors and by mixes of two and three sensors are shown in Table 1. For the single sensors, the highest number of targets was detected by the SS (90%) and the lowest by the PSID (66%). For both two- and three-sensor mixes, virtually all (96-100%) the targets were detected. In general, increasing the number of sensors from one to two resulted in a meaningful increase in detections. When the number was increased from

Table 1

PERCENTAGES OF TARGETS DETECTED WITH INDIVIDUAL SENSORS AND MIXES OF TWO AND THREE SENSORS (Starlight Illumination)

Number of Sensors	Sensor Combination	Description	Percent Detection
1	SS	1 SS	90
	HHTV	1 HHTV	84
	PPS-14	1 PPS-14	72
	PSID	1 PSID	66
2	I	2 SS	100
	II	1 SS 1 HHTV	97
	III	1 SS 1 PPS-14	99
	IV	1 HHTV 1 PPS-14	97
	V	1 SS 1 PSID	99
	VI	1 HHTV 1 PSID	96
3	VII	1 SS, 1 HHTV 1 PPS-14	100
	VIII	1 SS, 1 HHTV 1 PSID	99
	IX	2 SS, 1 HHTV	100

Table 2

PERCENT DETECTION AND QUALITY[a] OF DETECTION
(Starlight Illumination)

Number of Sensors	Combination	Detection	Detection + Distance	Detection + Size	Detection + Distance + Size
1	SS	90	31	82	29
	HHTV	84	23	72	20
	PPS-14	72	0	0	0
	PSID	66	63	0	0
2	I (SS,SS)	100	57	96	54
	II (SS,HHTV)	97	48	92	46
	III (SS,PPS-14)	99	34	82	30
	IV (HHTV,PPS-14)	97	27	80	24
	V (SS,PSID)	99	71	89	63
	VI (HHTV,PSID)	96	74	66	48
3	VII (SS,HHTV,PPS-14)	100	53	93	50
	VIII (SS,HHTV,PSID)	99	81	95	76
	IX (SS,HHTV,SS)	100	62	97	60

[a] Entries in each quality category represent the percentage of targets that were detected and for which correct estimates of distance or size, or both, were given.

two to three, improvement generally was negligible <u>when only the percent detections was considered</u>. If percent detections were the sole criterion, therefore, these results would strongly suggest that all mixes are about equally effective and that probably no more than two sensors need be used. However, when other measures of effectiveness such as quality and timeliness are considered, there are differences in the relative effectiveness of the mixes.

<u>Quality</u>. Table 2 shows the quality of target information supplied by the individual sensors and by the mixes. With the SS, for example, 90% of the targets were detected, accurate distance estimates were given for 31% of the targets, and accurate size estimates for 82%. Both correct distance and correct size were given for only 29%, primarily because of the inability of the operator to estimate accurately the distance of the target. With the HHTV, performance was somewhat lower than with the SS on all measures. No size information could be supplied by the PPS-14 or the PSID, but a response from a PSID operator was scored as correct on distance if he correctly reported which geophone was being activated. Thus, for the PSID, 66% of the targets were detected, with correct geophone reported for 63% of the targets.

The two-sensor mixes were about equally effective when only percent detections was considered. However, when quality of detections was considered, substantial differences were found. If distance is considered the most important quality, then the mixes that included the PSID (Mixes V and VI) were best; however, this advantage was lost if size was considered the most important quality. If both distance and size were considered simultaneously, and equally weighted, then the mix with one SS and a PSID (Mix V) was best.

Of the three-sensor mixes, Mix VIII was best, considering overall quality, and the qualitative information provided by Mix VIII was substantially better than that provided by the best of the two-sensor mixes. For example, complete data on the quality of information was provided on 76% of the targets with Mix VIII, as opposed to 63% with Mix V. To summarize, when only detections are considered, there are no differences within or between two- and three-sensor mixes. However, when quality of target information is considered, clear-cut differences emerge and provide a basis for selection of a best mix.

<u>Timeliness</u>. The third measure of effectiveness was timeliness of target detection. This measure showed the relative effectiveness of the sensors and mixes as the targets approached the squad line. Three criterion zones were used. The percentages of targets detected in these zones are presented in Table 3. The percentages shown in Zone 1 indicate that the target was detected at 200-300 meters, that in Zone 2 the target was detected at 100-300 meters, and that in Zone 3 the target was detected at 50-300 meters.

As was shown earlier, the mixes were about equally effective in terms of overall (Zone 3) detections. When the data were analyzed by zone (Table 3), no differences were found between Zone 3 and Zone 2.

Table 3

TIMELINESS OF TARGET DETECTION BY CRITERION ZONE
(Starlight Illumination)

Sensor Combination	Percent Detection, Criterion Zone 1	2	3
SS	49	84	90
HHTV	37	77	84
PPS-14	51	70	72
PSID	28	65	66
I (SS, SS)	67	95	100
II (SS, HHTV)	61	94	97
III (SS, PPS-14)	68	95	99
IV (HHTV, PPS-14)	65	94	97
V (SS, PSID)	58	93	99
VI (HHTV, PSID)	52	92	96
VII (SS, HHTV, PPS-14)	74	97	100
VIII (SS, HHTV, PSID)	69	97	99
IX (SS, HHTV, SS)	70	97	100

However, some differences were found in Zone 1, but these were not large and were mostly a consequence of sensor deployment. With the three-sensor mixes, differences in detection were negligible in all zones.

Detection, Timeliness and Quality. The full matrix for detection, quality, and timeliness is given in Table 4. From this table it can be seen that Mix VIII, with one SS, one HHTV, and one PSID, was the best overall mix.

Effects of Sensor Deployment. The effects of sensor deployment were examined to determine whether performance effectiveness of the mixes that contained a PPS-14 or a PSID was differentially affected by FAR and NEAR deployment of the sensors. FAR deployment for the PSID was at approximately 225-250 meters; for the PPS-14, the unit was remoted to 175 meters. NEAR deployment for the PSID was at approximately 125-150 meters; for the PPS-14, the unit was remoted to 35 meters.

Table 5 shows the percent detections, timeliness, and quality with the various mixes under FAR deployment conditions. On the detection measure the mixes did not differ. On overall quality, however, Mix V (with 54%) was the best of the two-sensor mixes and Mix VIII (with 72%) was the best of the three-sensor mixes.

Table 6 shows the same data for the NEAR deployment condition. For this condition, fewer targets were detected in Zone 1 with mixes that contained a PSID than with mixes that contained a PPS-14. However, the differences among the mixes disappeared in Zones 2 and 3. On overall quality, Mix V (with 72%) was again the best of the two-sensor mixes and Mix VIII (with 81%) was again the best of the three-sensor mixes.

To summarize, initially no differences among the mixes were found in detection, but in terms of overall quality of target information provided Mix V was found to be the best of the two-sensor mixes and Mix VIII the best of the three-sensor mixes. Also, more information was supplied with Mix VIII than with Mix V, a result demonstrating superiority of the three-sensor mix over the two-sensor mix, superiority not present when only detections were considered. The factor of sensor deployment was then examined to determine whether it modified these findings. Under both deployment conditions, Mixes V and VIII were found to be the best of the comparable mixes. Also, under both deployments, Mix VIII was superior to Mix V, the difference between the mixes being considerably larger under the FAR deployment condition.

Effects of Illumination. As illumination is a factor affecting performance with the SS, which was included in all of the three-sensor mixes, testing was also conducted under three-quarter to full-moon illumination. As was expected, increased illumination improved the quality of performance. The relative performance of the mixes under full-moon illumination is shown in Table 7. With the two-sensor mixes, there were no differences in either percent detection or overall quality except with Mix III. With this mix, overall quality was low because of lack of distance information from the PPS-14. Of the three-sensor mixes, two (Mix VIII and Mix IX) were considerably better in overall quality than any of

Table 4

PERCENT DETECTION, TIMELINESS, AND QUALITY
(Starlight Illumination)

Sensor Combination	Detection			Detection + Distance			Detection + Size			Detection + Distance + Size		
	Criterion Zone			Criterion Zone			Criterion Zone			Criterion Zone		
	1	2	3	1	2	3	1	2	3	1	2	3
SS	49	84	90	18	30	31	43	76	82	15	27	29
HHTV	37	77	84	10	22	23	31	66	72	9	19	20
PPS-14	51	70	72	0	0	0	0	0	0	0	0	0
PSID	28	65	66	27	62	63	0	0	0	0	0	0
I (SS,SS)	67	95	100	31	52	57	61	91	96	28	50	54
II (SS,HHTV)	61	94	97	25	45	48	55	88	92	23	43	46
III (SS,PPS-14)	68	95	99	21	33	34	46	76	82	18	29	30
IV (HHTV,PPS-14)	65	94	97	14	26	27	36	74	80	12	23	24
V (SS,PSID)	58	93	99	39	70	71	43	82	89	25	60	63
VI (HHTV,PSID)	52	92	96	34	73	74	26	60	66	11	44	48
VII (SS,HHTV,PPS-14)	74	97	100	32	51	53	59	89	93	29	48	50
VIII (SS,HHTV,PSID)	69	97	99	45	79	81	57	91	95	34	73	76
IX (SS,HHTV,SS)	70	97	100	35	58	62	65	94	97	33	55	60

Table 5

PERCENT DETECTION, TIMELINESS, AND QUALITY
UNDER FAR DEPLOYMENT CONDITION
(Starlight Illumination)

Mix	Detection			Detection + Distance			Detection + Size			Detection + Distance + Size		
	Criterion Zone			Criterion Zone			Criterion Zone			Criterion Zone		
	1	2	3	1	2	3	1	2	3	1	2	3
III (SS,PPS-14)	74	94	100	26	36	39	50	75	82	22	30	33
IV (HHTV,PPS-14)	72	94	99	17	25	25	36	72	76	14	21	21
V (SS,PSID)	70	96	100	55	61	62	44	82	89	31	49	54
VI (HHTV,PSID)	68	90	93	59	70	70	20	54	59	13	35	38
VII (SS,HHTV,PPS-14)	76	96	100	39	54	57	58	85	90	35	49	51
VIII (SS,HHTV,PSID)	77	99	100	62	75	76	56	93	96	41	68	72

Table 6

PERCENT DETECTION, TIMELINESS, AND QUALITY
UNDER NEAR DEPLOYMENT CONDITION
(Starlight Illumination)

Mix	Detection			Detection + Distance			Detection + Size			Detection + Distance + Size		
	Criterion Zone			Criterion Zone			Criterion Zone			Criterion Zone		
	1	2	3	1	2	3	1	2	3	1	2	3
III (SS,PPS-14)	63	97	99	17	31	31	42	79	82	14	28	28
IV (HHTV,PPS-14)	58	94	96	13	28	30	37	77	84	11	27	28
V (SS,PSID)	47	91	99	24	79	81	42	83	90	21	71	72
VI (HHTV,PSID)	38	89	93	10	75	78	33	67	73	10	53	58
VII (SS,HHTV,PPS-14)	71	100	100	25	49	51	61	94	96	24	48	49
VIII (SS,HHTV,PSID)	62	94	99	29	83	86	[illegible]	90	94	28	78	81

the two-sensor mixes, Mix VIII being the best of all the mixes. To summarize, Mix VIII with one SS, one HHTV, and one PSID was superior to the other mixes under both extremes of illumination.

False Reports. The percentage of false reports is an important factor in evaluating the effectiveness of the sensors and mixes. In the experimental design, one-third of the search periods contained no targets. Additionally, a false report could be made during the search periods which contained targets by "shooting" at a location that did not contain a target. Thus, there was ample opportunity to make false reports. The percentage of false reports (of total reports made) was higher with the HHTV (10%) than with the other sensors (2-3%). However, the efficacy of the three empirically tested mixes was not differentially affected, as all contained one HHTV.

Report to Squad Leader

The most common procedure in combat, upon detection of a target by an operator, is for the operator to report this information with no filtering to his squad leader. While there are many reporting procedures, the procedure used in the present experiment was to have the operator's runner verbally report to the squad leader. When the observer's data were compared with the information received by the squad leader, 98% of the reports to the squad leader were found to be identical to the original observer's report. Thus, loss of information was negligible and did not affect the efficacy of the mixes. It should be carefully noted that a minimum amount of information was communicated to the squad leader: Starlight Scope and HHTV operators reported size and distance, PPS-14 operators reported target in or out, and PSID operators reported the geophone number.

Report to the Platoon Leader

The conditions of the experiment required the squad leader to report target information to the platoon leader. The squad leader had the prerogative of deciding what information to report, and when. He could, if he decided it was a false report, not report it at all, or he could attempt to get confirmatory or more qualitative information and then report it. This procedure was employed to study potential control and communication problems. As the number of targets represented a low- to mid-intensity situation, and as the experimental design allowed for a large number of false reports, it was questionable whether the squad leader could handle a flow of information from his squad members and correctly pass the information back to his platoon leader. Additionally, it was possible that the squad leader, acting as a necessary filter, might degrade the flow of information and differentially affect the efficacy of the mixes.

Table 7

PERCENT DETECTION, TIMELINESS, AND QUALITY
UNDER COMBINED DEPLOYMENT CONDITIONS
(Full-Moon Illumination)

Mix	Detection			Detection + Distance			Detection + Size			Detection + Distance + Size		
	Criterion Zone			Criterion Zone			Criterion Zone			Criterion Zone		
	1	2	3	1	2	3	1	2	3	1	2	3
I (SS,SS)	79	97	100	39	58	63	77	97	100	39	58	63
II (SS,HHTV)	69	95	98	44	62	64	69	93	95	44	61	63
III (SS,PPS-14)	70	97	98	22	33	35	59	80	84	22	32	33
V (SS,PSID)	79	93	97	54	75	75	66	84	88	44	68	68
VII (SS,HHTV,PPS-14)	71	98	100	47	63	63	69	95	97	47	63	63
VIII (SS,HHTV,PSID)	80	96	98	63	86	86	74	93	96	58	83	83
IX (SS,HHTV,SS)	80	97	100	50	70	76	78	97	100	50	70	76

Table 8

COMPARISON OF OBSERVER REPORT WITH REPORT TO PLATOON LEADER
UNDER COMBINED DEPLOYMENT CONDITIONS
(Starlight Illumination)

Mix	Detection		Detection + Distance		Detection + Size		Detection + Distance + Size	
	Obs Rpt	Rpt to Plt Ldr	Obs Rpt	Rpt to Plt Ldr	Obs Rpt	Rpt to Plt Ldr	Obs Rpt	Rpt to Plt Ldr
VII (SS,HHTV,PPS-14)	100	97	53	36	93	78	50	33
VIII (SS,HHTV,PSID)	99	94	81	53	95	84	76	46
IX (SS,HHTV,SS)	100	97	62	34	97	92	60	32

A comparison of the observer report with the information reported to the platoon leader is given in Table 8 for the starlight illumination condition. (Similar effects were observed in the moonlight condition.) Loss of information was considerable with all mixes, ranging from about one-third with Mix VII (from 50% overall quality in the original report to 33% in the report to platoon leader) to nearly half with Mix IX (60% in original vs. 32% in platoon leader report). The largest absolute degradation in quality occurred with Mix VIII (76% to 46%), but even with this loss this mix remained superior to the other mixes.

The results show clearly that a large loss in quantity and quality of information available to the squad leader occurs when he, using his best judgment, filters the information which he thinks suitable for retransmission.

SUMMARY

This report is an interim report on the second portion of a two-part field experiment. A final report will provide an integrated analysis and conclusions based upon data from both parts. The present data show that a higher quality of target information is obtained with the mix containing one PSID, one Starlight Scope, and one Thermal Viewer than with the other mixes tested.

All mixes showed a large loss of information as reports were transmitted from squad leader to platoon leader, particularly with regard to quality of target information. This result strongly suggests the need for better training of the squad leader on reporting information, or improved methods and techniques for transmitting target data, or a combination of the two.

APPENDIX

TARGET REPORT FORMS

PROCEDURE

The sensor operator pressed a response button when he detected a target, and then reported information about the target to his data collector/runner. The data collector/runner entered the information on a target report form which he delivered to a controller located with the squad leader. The controller then recorded on the form the content of the data collector/runner's verbal report to the squad leader, as well as the actions of the squad leader. Samples of the report forms for the four sensors used (Starlight Scope, Hand-Held Thermal Viewer, PPS-14 Radar, PSID) are included in this appendix.

DESCRIPTION

The forms for all sensors were identical in format, actual content being adjusted according to the nature of the information supplied by a given sensor. All information necessary for identification of a report was entered by the experimenters on the first line of the form. The body of the form was broken into three sections: observer report, report to squad leader, and squad leader's action.

Observer Report. The observer report was filled out by the data collector/runner. On all forms, the first item to be entered was the counter number. This number was obtained from an incremental counter located in the player booth, which was activated each time the sensor operator pressed his response button, an identical number being simultaneously recorded on magnetic tape of the data acquisition system. (This technique permitted combining the information contained in the report form with the corresponding information recorded on the magnetic tape.) As can be seen from the sample report forms, the target information that could be supplied was different for the four sensors. Also, for the SS, the data collector/runner was required to record whether the target had been found by the sensor operator working independently or by the sensor operator after the squad leader had sent a runner with information about the target from an earlier acquisition. (For example, the target might have been detected first by the PSID and the squad leader might direct the runner to go to a booth with a SS and tell the operator to look in the area of geophone #3.)

Report to Squad Leader. After entering the information in the Observer Report section, the data collector/runner delivered the report form to the controller with the squad leader. The runner then verbally reported the information to the squad leader, while the controller recorded on the form the content of the verbal report.

Squad Leader's Action. This section was divided into two subsections. In the first (Squad Action), the controller recorded the squad leader's actions involving use and disposition of the members of his squad. For the SS and HHTV, the squad leader had to instruct the runner whether his sensor operator (the original observer) should continue to observe the same target or should break contact with that target to search for new targets. In addition, he had the option of sending the runner to another squad member with a SS to request confirmation and/or additional information about the target. With the PPS-14 and PSID, since operators could not break contact with a target at will, the squad leader could only return the runner to his own booth or send him to another booth with a SS for additional information.

The conditions of the experiment also required the squad leader to report target information to his platoon leader, but he had the responsibility of deciding what information to report, and when. In the second subsection (Platoon Action), the controller recorded this aspect of the squad leader's behavior noting whether he would report and the content of his report, or would not report, or had already reported the information from an earlier acquisition of the target.

STARLIGHT SCOPE

REPORT FORM

Device	Night	Squad	Booth	Deployment	Mix	Player	Sheet No.
1							

Observer Report	Counter Number	______
	Number of Personnel	______
	Range in Meters	______
	By Myself	______
	Found Target — After directions from Squad Leader	______
Report to Squad Leader	Number of Personnel	______
	Range in Meters	______
Squad Leader's Action	Squad Action — Original Observer (Stay on Target	______
	(Search for other Targets	______
	Request confirmation from Position(s)	______ ______
	Platoon Action — I would report to Platoon Leader (Number of Personnel	______
	(Range in Meters	______
	I would not report to Platoon Leader	______
	I have already reported this information to Platoon Leader	______

PPS-14

REPORT FORM

Device	Night	Squad	Booth	Deployment	Mix	Player	Sheet
2							

Observer Report		Counter Number ______
	Target Moving	(Toward Me ______ ((Away from Me ______
Report to Squad Leader	Target Moving	(Toward Me ______ ((Away from Me ______
Squad Leader's Action	Squad Action	Return Runner to own Booth ______ Request confirmation from Position(s) ______ ___
	Platoon Action	I would report to Platoon Leader .... (Toward ______ ((Away ______ I would not report to Platoon Leader ______ I have already reported this information to Platoon Leader ______

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PSID

REPORT FORM

Device	Night	Squad	Booth	Deployment	Mix	Player	Sheet
3	____	____	____	________	__	_____	____

Observer Report		Counter Number ________ Geophone Number (circle one) 1 2 3 4
Report to Squad Leader		Geophone Number (circle one) 1 2 3 4
Squad Leader's Action	Squad Action	Return Runner to own Booth ________ Request confirmation from Position(s) ________
	Platoon Action	I would report to Platoon Leader Geophone Number (circle one) 1 2 3 4 I would not report to Platoon Leader ________ I have already reported this information to Platoon Leader ________

THERMAL VIEWER

REPORT FORM

Device	Night	Squad	Booth	Deployment	Mix	Player	Sheet No.
4							

Observer Report		Counter Number	____
		Number of Personnel	____
		Range in Meters	____
	Found Target	By Myself	____
		After directions from Squad Leader	____
Report to Squad Leader		Number of Personnel	____
		Range in Meters	____
Squad Leader's Action	Squad Action	Original Observer (Stay on Target	____
		(Search for other Targets	____
		Request confirmation from Position(s)	____
	Platoon Action	I would report to Platoon Leader (Number of Personnel	____
		(Range in Meters	____
		I would not report to Platoon Leader	____
		I have already reported this information to Platoon Leader	____

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13. ABSTRACT

Continuing research is being conducted by the Behavior and Systems Research Laboratory in the STANO Performance Optimization Program (formerly Night Operations) directed toward enhancement of combat soldier performance in night operations utilizing night vision devices and related sensors. This program is being executed by the BESRL Field Experimentation Unit at Fort Ord, California in conjunction with and with the support of the Combat Developments Experimentation Command (CDEC). The present experiment is designed to provide comparative performance data on the effectiveness of small units utilizing six different mixes of STANO sensors.

The findings of PART I of the experiment, in which three mixes were empirically tested and others analytically evaluated under two sensor deployment conditions in a linear defense situation, are reported in an earlier publication (Technical Research Note 237). The present publication reports on PART II of the experiment covering evaluation of three additional mixes tested under the same conditions in the linear defense situation and in a reconnaissance patrol situation. A final report will provide integrated analyses and conclusions based on all data accumulated.

Testing for PART II of the experiment was conducted under starlight and three-quarter to full-moon illumination conditions. Eighteen squads were tested on each of three mixes (with three sensors per mix) for two tactical deployments of the sensors. For each mix a total of 144 targets were presented under starlight, a total of 72 targets under moonlight. Sensors employed included the Starlight Scope, AN/PVS-2 (SS),

14 KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
*STANO sensors						
*Unit (small) effectiveness						
*Night vision devices						
*Sensor systems						
*Mixes						
*Night operations research						
Starlight conditions						
Sensor operator						
Search techniques						
Work methods						
Team procedures						
Deployment conditions						
Command & control techniques						
*Communication procedures						
Field experimentation						
Instrumentation						
Research methodology						
*Starlight scope (SS)						
*Radar (PPS-14)						
*Patrol Seismic Intrusion Device (PSID)						
*Hand-held Thermal viewer						
PSID geophones						
sensor deployment						
Target detection						
Data acquisition system						
Military psychology						

DD Form 1473

13. ABSTRACT - Continued

Listening Post Surveillance Device, AN/PPS-14 (PPS-14), Patrol Seismic Intrusion Device, AN/GSQ-151 (PSID), and Hand-Held Thermal Viewer, AN/PAS-7 (HHTV). The data were analyzed in terms of 1) observer reports, 2) reports to squad leader, and 3) reports to platoon leader. Comparisons were made for individual sensors, mixes involving two sensors, and mixes involving three sensors.

Results showed that a higher quality of target information is obtained with the mix containing one PSID, one SS, and one HHTV than with the other mixes tested. All mixes showed a substantial loss of information as reports were transm :ted from squad leader to platoon leader, particularly with regard to quality of information. Under high illumination, quality of performance improved for mixes containing a Starlight Scope. The number of false reports was small for all sensors and mixes, but was higher for the HHTV than for the other sensors. Results strongly suggest the need for improved procedures or more adequate training, or both.

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