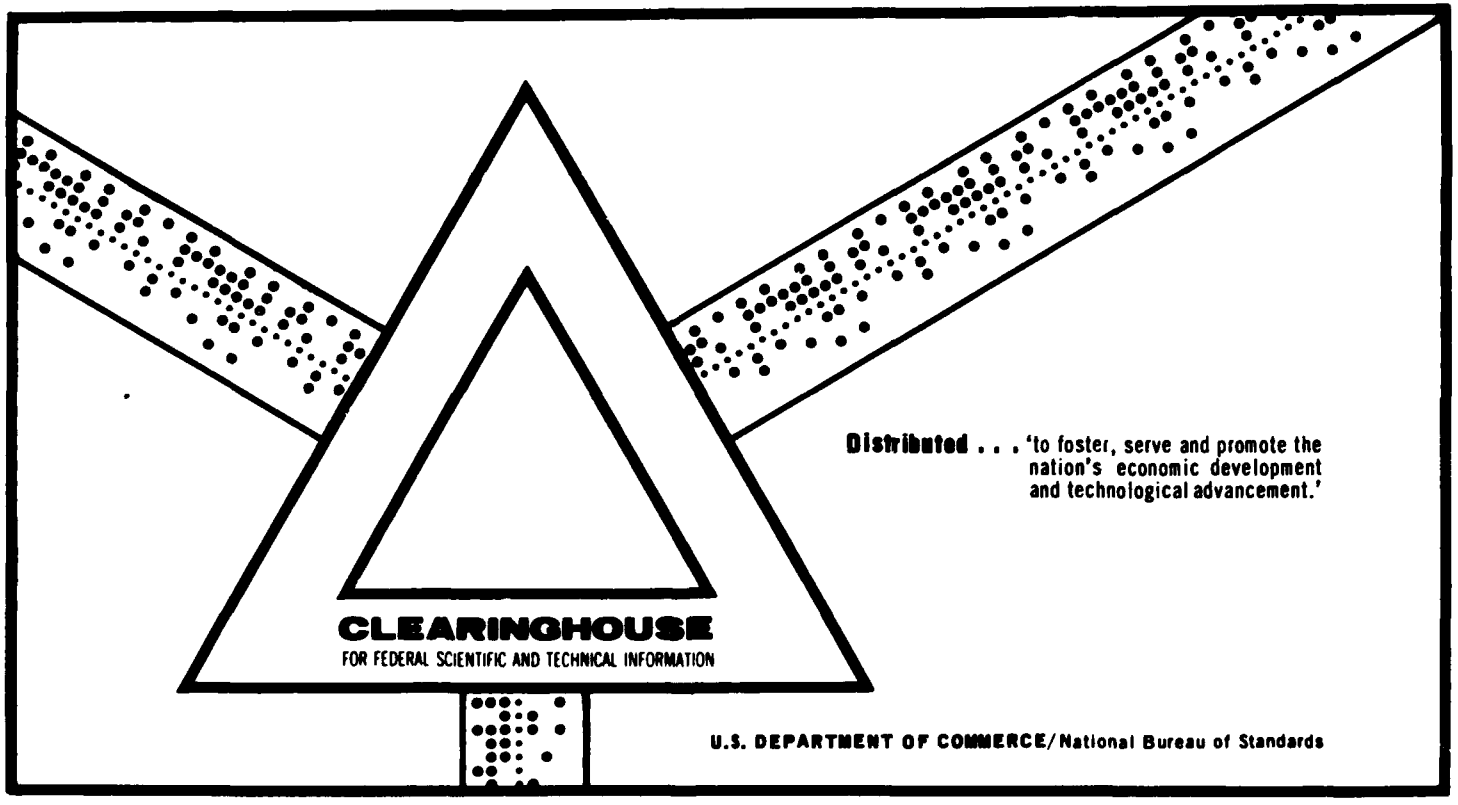
SQUAD PERFORMANCE AS A FUNCTION OF THE DISTRIBUTION OF A SQUAD RADIO

James W. Dees

Human Resources Research Organization
Alexandria, Virginia

December 1969



Technical Report 69-24

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Contract DAHC 19-70-C-0012

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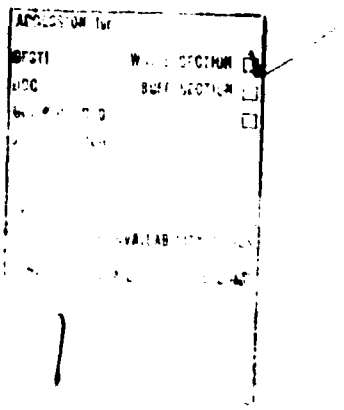

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HumRRO Division No. 4
Fort Benning, Georgia
HUMAN RESOURCES RESEARCH ORGANIZATION

Technical Report 69-24
Work Unit CONTROL

The Human Resources Research Organization (HumRRO) is a nonprofit corporation established in 1969 to conduct research in the field of training and education. It is a continuation of The George Washington University Human Resources Research Office. HumRRO's general purpose is to improve human performance, particularly in organizational settings, through behavioral and social science research, development, and consultation. HumRRO's mission in work performed under contract with the Department of the Army is to conduct research in the fields of training, motivation, and leadership.

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FOREWORD

The study described in this report resulted from a research requirement, originated by the U.S. Army Combat Developments Command Infantry Agency (USACDCIA), to determine the optimum distribution of the squad radio within the infantry squad and to determine the effect of the use of the radio on peripheral hearing and/or the other senses. The study was part of the research conducted by the Human Resources Research Organization under Work Unit CONTROL, which deals with control in small infantry units. The research was performed and most of the report preparation completed while HumRRO was part of The George Washington University.

Research for this study was conducted at HumRRO Division No. 4 (Infantry), Fort Benning, Georgia. Dr. James W. Dees was Work Unit Leader. Dr. T.O. Jacobs is Director of Research of HumRRO Division No. 4 and LTC Chester I. Christie is Chief of the co-located U.S. Army Infantry Human Research Unit (USAIHRU). LTC F.O. Barger, Jr., who was Chief of the USAIHRU at the time the research was conducted, was of major assistance in obtaining, on short notice, the resources and facilities necessary for the study and in developing and running the experiments.

Mr. George J. Magner of HumRRO wrote the scenarios with the assistance of 2LT Ruben M. Kuratli of USAIHRU, who also served as OIC and platoon leader/controller for the study. SFC John D. Loomis of USAIHRU served as NCOIC for the problem and was very effective in his work with the troops and controllers throughout the problem. USACDCIA personnel were LTC Paul R. Whaley, who secured the radio sets from private sources, and MAJ Michael Horan and CPT Raymond C. Fields, who served as liaison officers between USACDCIA and HumRRO. Mr. Lyman K. Harris of HumRRO developed the recording equipment and Mr. Prince E. Jones of HumRRO operated it. Additional USAIHRU personnel who served as controllers, instructors, or technical assistants were CPT James B. Walker, 1LT Raymond J. Novotny, SFC Walter Barefoot, PSG James J. Lee, SFC Charles S. Elledge, SSG Bobby D. French, SP4 James H. Cross, SP4 Dennis I. Jarden, SP4 Gerald E. Ollie, PFC Gerald J. Munko, PFC Bruce W. Jorgenson, and PFC Richard G. Berry.

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Meredith P. Crawford
President
Human Resources Research Organization

Military Problem

Span of control, one of the most frequently studied subjects in the United States Army, concerns the number of men and/or elements that a single man can successfully control. In infantry combat, the training of the men, the type of terrain, the quality of communication, and many other factors affect this span of control. The miniaturization of two-way radios has made it practical to have radio communication within the squad and platoon. One of the important questions to be answered before radios are made available at the platoon and squad level is, "What is the optimal distribution of the radio within the platoon and squad?"

Approach

In a survey of the relevant scientific literature, no studies were found which provided information on a distribution of the radio within the platoon for optimum efficiency.

As it was desired to measure the total impact of the radio upon squad performance rather than measure its impact upon communications alone, a tactical problem was developed to represent the kinds of tasks that normally might be performed by an infantry rifle squad in decentralized company operations. The problem incorporated three typical combat situations: (a) an approach to contact in heavy vegetation with an assault, (b) an approach to contact in limited visibility with a limited visibility assault, and (c) a limited visibility defense. The three general phases developed for the problem were a daylight search-and-destroy operation ending with an assault, a night raid, and a night defense.

During each of the three phases, the squad being tested acted as one squad in a platoon that was, in turn, operating as a part of a company in a decentralized operation. The other two rifle squads in the platoon were not present, being represented by NCOs who provided squad leader level input into the platoon radio and, at appropriate times, fired blanks to simulate the fire that would have been delivered by the members of the other squads had they been present.

Squad performances were tested on two factors: the times required to accomplish a series of specific actions, and the rated effectiveness of the squads on such variables as noise discipline, dispersion, and keeping leaders informed of the situation.

Results

(1) Considering results of alternate statistical analyses, four of the 12 time measures showed statistically significant differences among the radio distribution conditions. The functions assessed in these measures were (a) communication and deployment, (b) communication under fire (twice), and (c) communication at night. The radio distribution with the lowest mean time in three of the four significant measures was Distribution 2, two-way communication between platoon leader and squad leader.

(2) The mean times for the various radio distribution conditions suggest that performance was not affected to any great extent if squad members other than the leader had receivers, but that the distribution of transmitters to squad members had a negative effect.

(3) Ratings of squad proficiency in performing the tactical problem yielded only one significant rating out of 121 rating situations, suggesting that (a) there was little real difference between the eight radio distributions studied, and (b) what difference did exist was detected more readily by the more objective time measures than by the proficiency ratings.

Conclusions

(1) Low density distribution of the radio appears to be more effective than high, with two-way communication between the platoon leader and the squad leader being optimal.

(2) The radio communication capability seems to be most valuable under enemy fire and/or in limited visibility.

(3) It appears to make little difference whether members of the squad other than the squad leader have receivers. However, distribution of the transmitter below the level of the squad leader seems to have a deleterious effect on squad effectiveness.

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Squad Performance as a Function of the Distribution of a Squad Radio

INTRODUCTION

MILITARY PROBLEM

Study of the control of tactical units has a long history in the U.S. Army. The question of span of control—the number of men and/or elements that a single man can successfully control—has been one of the most frequently studied sub-areas of the problem.

In infantry combat, several factors affect the span of control. Among these are the training of the men, the type of terrain, and the quality of communication. The establishment of standing operating procedures (SOPs) through training integrates the actions of individuals into team efforts, thereby reducing control requirements. Terrain and climate conditions affect quality of communications, thereby affecting the quality of control. All other things being equal, improved communications will yield improved control.

However, various communication devices have their own requirements, some of which often offset the benefits of good control by impeding effective performance. For example, use of a radio may interfere with hearing other important sound cues while on a mission. As another illustration, hand-and-arm signals are excellent communitcation devices, but often draw heavy enemy fire to the man using them.

The miniaturization of two-way radios has made possible their distribution to any or all of the members of the platoon. However, the goal is not simply to increase communication, or even to increase control, but to increase the proficiency of the platoon and squad. While a wide distribution of a two-way radio within a platoon would increase the range, reliability, and speed of communication, the radio is a piece of equipment that must be manipulated and monitored. Thus, the radio will increase the work load and the monitoring requirements of the individuals using it.

There is wide leeway in deciding on a distribution of the radio within the platoon which offers an optimum combination of advantages and disadvantages. The purpose of this research was to identify that distribution.

RESEARCH APPROACH

A survey of the relevant scientific literature yielded information only of ancillary interest and importance, principally in the psycho-physiological areas of audition.[1] No studies were found which dealt specifically with the problem at hand.

For a specific problem, ideally the scientific literature should furnish mathematical definitions of the parameters, sufficient in detail to allow a reliable prediction to solve the problem. In the area of human performance, however, the state of the art is such that, more often than not, the definitions and

[1]The literature survey is summarized in an annotated bibliography at the end of this report.

data available in the literature are insufficient for complex problem solving. In this situation, an applied study is often used to provide specific answers to specific questions without providing a mathematical definition of the parameters involved. The advantage of this approach lies in the potential rapidity with which a specific problem can be resolved; its greatest disadvantage is the limited generalizability of the results. If the conditions of combat are adequately simulated, and if adequate criteria of proficiency are established, the radio distribution which optimizes proficiency in the simulation should optimize proficiency in combat.

Therefore, squad performance as affected by a varied radio distribution was tested by using simulations of actual combat situations. This method measures the total impact of the radio upon squad performance, not only its impact on communications. For the results to be valid, the simulation must be a valid representation of actual combat. The conditions of the simulation developed in this study are explained in considerable detail in this report and in Appendix A to provide documentation for assessing the validity of the simulation. Probably the most important discrepancies between the simulation developed in this study and actual combat are: (a) the absence of real casualties, and (b) the restriction against innovative changes in tactics. The first discrepancy is intrinsic to any simulation of a combat environment; the second was a necessary condition to standardize the experimental situation.

PROCEDURE

RADIO EQUIPMENT USED

The squad radio utilized consists of separate receiving and transmitting components, designated the AN/PRR-9 and AN/PRT-4 respectively. The receiver is equipped with both a speaker and an earplug, the use of the earplug disconnecting the speaker circuit. A squelch circuit is available which virtually eliminates the noise commonly associated with ultra-high frequency (UHF) communications equipment. The tuning is preset by a single crystal which may be interchanged to obtain a different frequency. The transmitter has two channels: one with a range of approximately 1,600 meters (one mile), the other with a range of approximately 300 meters. These channels are also pretuned with interchangeable crystals. In addition to voice communications, the transmitter has a beacon which can be used for code signals.

The receiver would normally be either carried in a shirt pocket or clipped to the helmet. The transmitter would normally be either hand-carried or worn clipped to the webbing.

THE TACTICAL PROBLEM

A squad tactical problem was developed, representative of the kinds of tasks that might normally be performed by an infantry rifle squad in the type of decentralized company operations common in Vietnam. To make the command and control requirements representative, the problem dealt with three typical combat situations: an approach to contact in heavy vegetation with an assault, an approach to contact in limited visibility with a limited visibility assault, and a limited visibility defense. These three situations were interpreted into a tactical problem with three distinct phases:

(1) A daylight search-and-destroy operation ending with an assault.
(2) A night raid.
(3) A night defense.

In each of the phases, special events were imposed to present communication requirements to the squad, which then served as the basis for measurement of relative effectiveness in both communications and squad performance in coping with mission requirements.

During each of the three phases, the squad acted as a part of a platoon that in turn was operating as a part of a company in a decentralized operation. The other two rifle squads of the platoon were not actually present; they were represented by noncommissioned officers who provided squad-leader level input into the platoon radio net, and fired blanks at appropriate times to simulate the fire that would have been delivered by full squads. The "platoon leader," a lieutenant, was both a research team observer and a participant. In his role as participant, he occupied the normal position behind the test squad and provided consistent leadership to the extent that the situations permitted.

The three phases in the overall problem and the special situations within phases (summarized in Table 1) were as follows:[1]

(1) Search and Destroy Operation. A schematic map of the search-and-destroy operation is shown in Figure 1. The test squad was informed that it would be the point squad for the platoon and was briefed on the general situation. In this phase, the several special events encountered by the squad were

Table 1

Critical Events of the Squad Problem

Search-and-Destroy (Day)	Night Raid	Night Defense
1. Movement	8. Movement	14. Defense position
2. Boobytraps	9. Approach to village	15. Listening post
3. Enemy equipment	10. Fire fight	16. Enemy attack
4. Sniper	11. Search	17. Reorganization
5. Small group of enemy	12. Movement	
6. Assault of enemy position	13. Medical evacuation	
7. Search		

designed to represent a typical approach and discovery of a small enemy supply base: boobytraps on the trail being used, some enemy equipment located just off the trail, sniper fire, and fire from a small group of three aggressors. Finally, the squad was required to assault the enemy supply base when the other two squads (simulated) were pinned down by heavy enemy automatic weapons fire. After the supply base was seized, the additional requirement to reorganize and search the area completed the search-and-destroy phase of the problem.

(2) Night Raid. A schematic map of the night raid area is shown in Figure 2. The squad was told that intelligence had been received indicating that the enemy was using a small jungle village as a rest and resupply point. The platoon's mission was to conduct a night raid on this village to kill or capture the enemy. The squad was told that they had made a clandestine early morning entry into the area and during daylight had moved to within 1,000 meters of the village without being detected. Small reconnaissance patrols had found suitable

[1]A complete description of the problem will be found in Appendix A, which contains scenarios for the three phases, the measurements made at various points during the problem, the training program of controller and aggressor personnel, and the experiment calendar.

Search-and-Destroy Operation Area

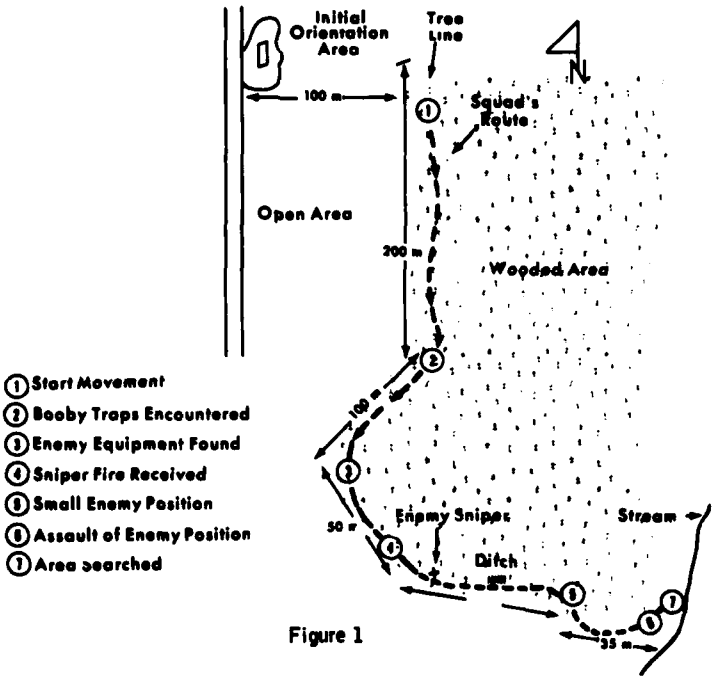

Figure 1

Night Raid Area

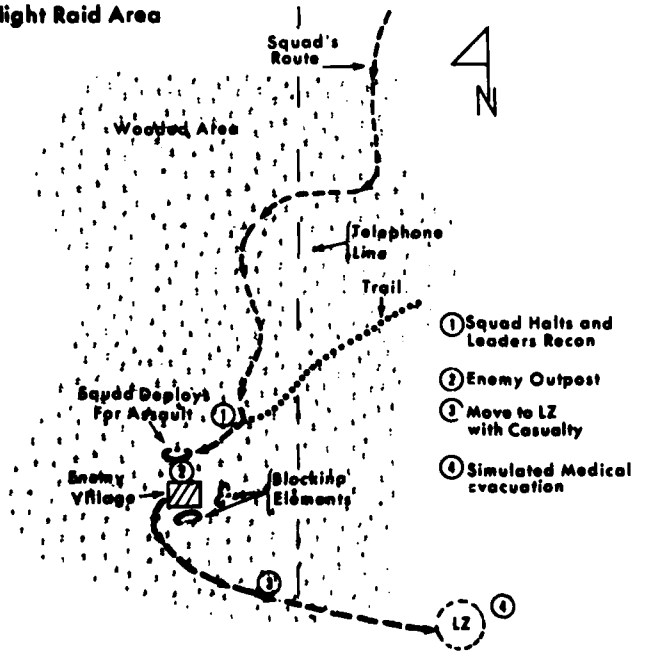

Figure 2

night approaches. The squad was then briefed on the routes to be followed and the specific missions of each of the squads.

To begin the special events for this phase, the test squad was given the mission of leading the platoon in the approach to the enemy village, and then holding in position outside the village while the other two squads maneuvered into blocking positions on the far side of the village. When the second and third squads reported that they were in position, the squad leader of the first squad moved forward in an attempt to make a surprise assault on the village. Discovery by an enemy outpost which fired and withdrew was followed by a brief fire fight with the aggressors in the village, the overrunning and search of the village by the test squad, the evacuation of a non-walking, seriously injured casualty (simulated), and movement to and securing of a medical-evacuation landing zone.

(3) Night Defense. After the simulated medical evacuation of the non-walking casualty, the platoon received orders to move back to the vicinity of the enemy village to complete the search of the village the following morning. The platoon leader selected a location for the formation of a platoon perimeter defense for the rest of the night and the platoon was directed to move silently into the selected position (shown in Figure 3). The squad leader was assigned a portion of the platoon perimeter to organize and defend. The special events in the night defense phase were the occupation and organization of the defense position, the establishment of a three-man listening post on a trail leading into the defense position, several enemy probes of the perimeter, and a reorganization which followed the last of the probes and ended the problem.

Night Defense Area

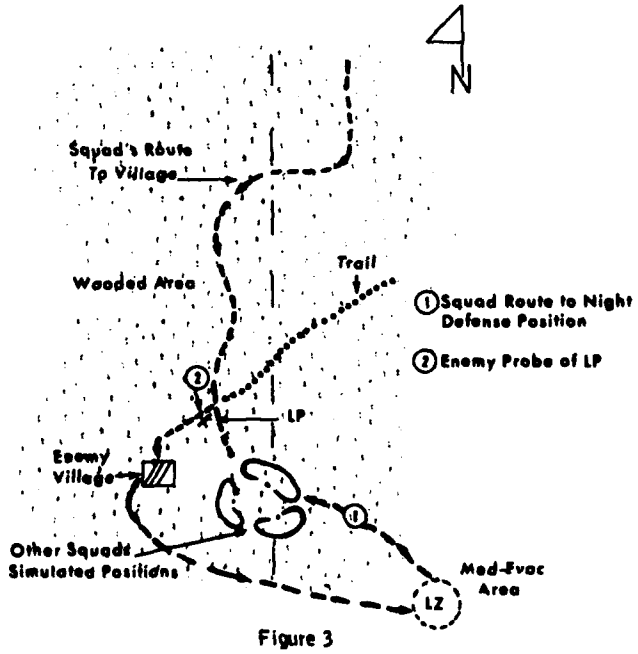

Figure 3

RADIO DISTRIBUTION

Two radio nets were involved in the research: a platoon net and a squad net. Within the platoon net there were four logical possibilities of radio communication: no radio, transmission from platoon leader (PL) to squad leader (SL), the reverse, and two-way transmission between platoon leader and squad leader. Only the first and last of these were considered for the platoon net. Among the 10 members of a squad, there are 4^{10} possible patterns of radio distributions. By dividing the squad into the three leadership levels of squad leader, fire team leader (FTL), and fire team member, and requiring that all men at equal or superior leadership levels have at least the same radio capability as their peers or subordinates,[1] the number of combinations was reduced to 16, including the platoon net combinations. These 16 distributions were then reduced to eight to be used in the experiment, through consultation with the requesting agency, the U.S. Army Developments Command Infantry Agency (USACDCIA).

The eight distributions used in the study are presented in Table 2. Distribution 1 was a no-radio control condition, and Distribution 2 was a second type of control condition in which no squad member had a radio except for the squad leader, who was linked by a platoon net to the platoon leader. Distributions 3 through 8 included various types of squad radio nets, the differences being the ways that transmitters and receivers were distributed among the squad members. For example, transmitters were used by some squad members in Distributions 5 through 8, but not in Distributions 3 and 4.

Table 2

Radio Distributions

User	No Radio	PL and SL Transmit			PL, SL, and FTL Transmit			All Transmit
	1	2	3	4	5	6	7	8
Platoon Leader (PL)		TR[a]	TR	TR	TR	TR	TR	TR
Squad Leader (SL)		TR	TR	TR	TR	TR	TR	TR
Fire Team Leader (FTL)			R	R	TR	TR	TR	TR
Buddy 1				R		R	R	TR
Buddy 2				R			R	TR

[a]T = Transmitter, R = Receiver

Since the AN/PRR-9 receives only one channel, a potential problem arose for the squad leader because he was required to receive transmissions on both the platoon net and the squad net in Distributions 5 through 8. Therefore, it was necessary for him to carry two receivers—one to receive transmissions on the platoon net, and the other to receive transmissions originating within his own squad net.

PERFORMANCE MEASURES

Two kinds of data were recorded as performance measures. These consisted of the times required for the squad to perform various operations, and

[1]*Except for one buddy pair, where only one in the pair had a radio.*

the ratings by research personnel observing the squad and fire team to determine the effectiveness of the squad in accomplishing its assigned tasks. If the squad radio impacted favorably on squad controllability without detracting in other areas such as performance, some or all of the measures should reflect differences from one radio distribution to another.

The participants were observed by controller teams of six research staff members each, to note when events occurred and to rate performance. Controllers accompanied squad and fire team leaders; one was also at the recording station. Each controller had a radio; communications between controllers were on their own controller net.

Time Measures

The various time measures that were obtained during the three phases of the experimental problem are presented in Table 3. The time data were obtained by recording each of three radio nets: the platoon and squad nets which comprised the experimental conditions, and the controller net used by the research staff. To facilitate the precise determination of various elapsed times, each of the nets was fed into one track of a stereo tape recorder while a standard time baseline (the output of a monaural tape recorder) was fed simultaneously into the other track of each of the three recorders.

Table 3

Time Measures

Phase	Events	Function Measured
Day Search-and-Destroy Operation	1. Booby Trap: From Point 1 to PL acknowledges receipt of boobytrap information (1 & 2)[a]	Perception and communication of situation
	2. Equipment: From Point 2 to PL acknowledges receipt of equipment information (6 & 7)	Perception and communication of situation
	3. New Trail: From PL orders squad to proceed down new trail to Point 3 (8 & 9)	Communication and deployment
	4. Sniper: From point man hit by sniper fire to PL acknowledges information (12 & 14)	Communication under fire
	5. Report Enemy Fire: From small enemy group opens fire to PL acknowledges message (18 & 19)	Communication under fire
	6. Reaction to Fire: From small enemy group opens fire to squad on line and returning fire (18 & 20)	Deployment by SOP—communication optional
	7. Assault: From SL acknowledges order to assault to squad deployed and in assault (24 & 25)	Communication and deployment under fire
Night Raid	8. Approach to Village: From SL acknowledges order to approach village to squad deployed in approach (32 & 33)	Communication and deployment

(Continued)

Table 3 *(Continued)*

Time Measures

Phase	Events	Function Measured
	9. Casualty: From sniper opens fire to PL acknowledges wounded man information (37 & 38)	Communication under fire
	10. Landing Zone: From PL orders squad out of village to squad deployed in LZ (42 & 43)	Communication and deployment at night
Night Defense	11. Defense: From PL receives instructions to order squad to defense position to satisfactory deployment (47 & 49)	Communication at night
	12. Listening Post: From PL requests LP to LP set up (54 & 55)	Communication and deployment at night

[a]Numbers in parentheses refer to controller functions listed in the Control Plan in Appendix A.

Thus, using the common time baseline, it was possible to compare the three tracks constituting the three radio nets, and to obtain precise elapsed times from the issuance of commands from the platoon leader (as recorded on the platoon net) to the accomplishment of the command by the squad (as reported by one of the controllers on the controller net).

Similarly, it was possible to determine the time required for transmission of information within the platoon by determining the time that a given event occurred (from studying the recording of the controller net) until the time at which the platoon leader acknowledged receipt of the information (determined from the recording of the platoon net). The various points at which controllers were to report the occurrence of events were specified in the control plan (Appendix A), wherein controllers were given standard instruction during practice runs of the problem concerning the various points that were to be reported.

Proficiency Ratings

The variables on which proficiency ratings were obtained from controller personnel are shown in Table 4; the rating areas applied to the specific situations within each of the three problem phases are presented in Figures 4, 5, and 6.

To facilitate the process of rating the squad proficiency, controllers in the field were given instructions and reminders from a centrally located controller, who announced the appropriate events to be rated over the controller net. This was particularly necessary in darkness, when rating sheet instructions were hard to read. In any case, the reminders were helpful in coordinating the controllers' tasks. This procedure permitted controllers to make their ratings at the appropriate time with minimum interference with the continuation of the operation, and under any conditions of visibility. The ratings themselves were made by the controllers on a small pad of writing paper, one rating to the page. Controllers consolidated their ratings immediately following each phase by transferring the ratings from the separate sheets of notepaper to a consolidation sheet.

Table 4

Proficiency Ratings

General Rating Areas

1. Noise discipline
2. Visual contact maintained by point element
3. Visual contact maintained by flank security element
4. Squad controllability
5. Efficiency of squad's regrouping and continuation of movement
6. Skill in following designated procedures
7. Squad dispersion during movement
8. Squad dispersion when column halted
9. Squad dispersion during defensive posture
10. Coordination of movement between fire teams
11. Keeping squad leader well informed at all times
12. Keeping fire team leaders well informed of the situation at all times

Specific Ratings

1. Squad's effectiveness at finding the remaining boobytraps (day)
2. Search organization and thoroughness (raid)

Rating Areas Applied to Search-and-Destroy Events

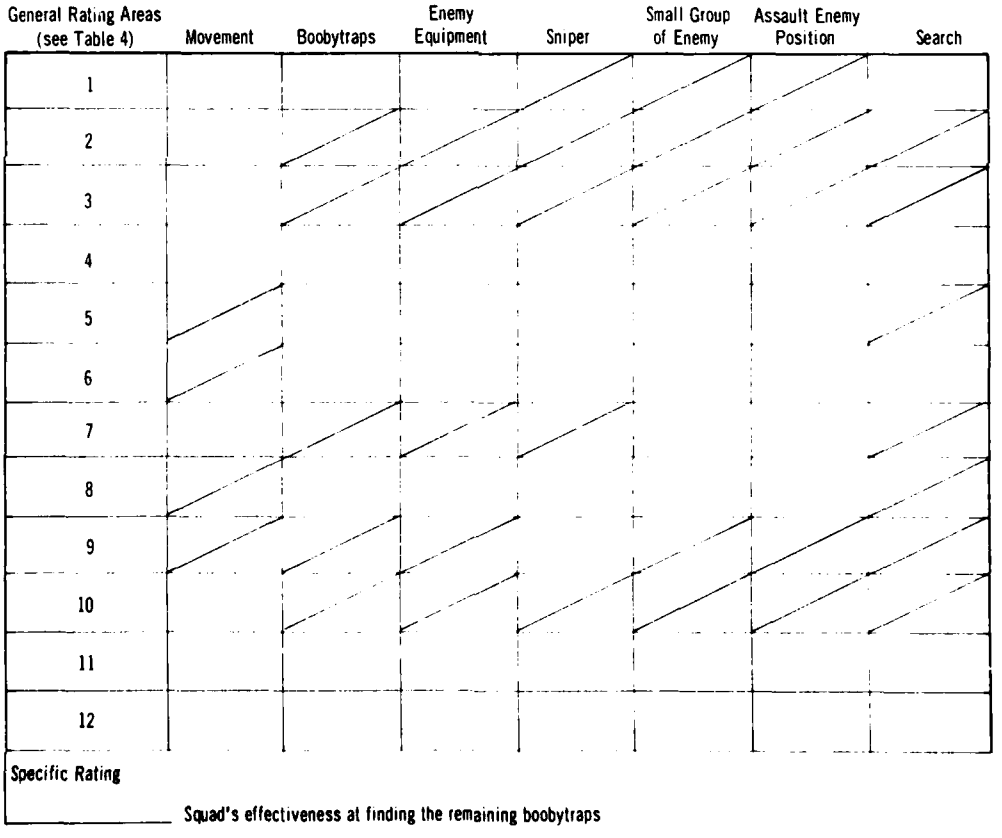

Figure 4

Rating Areas Applied to Night Raid Events

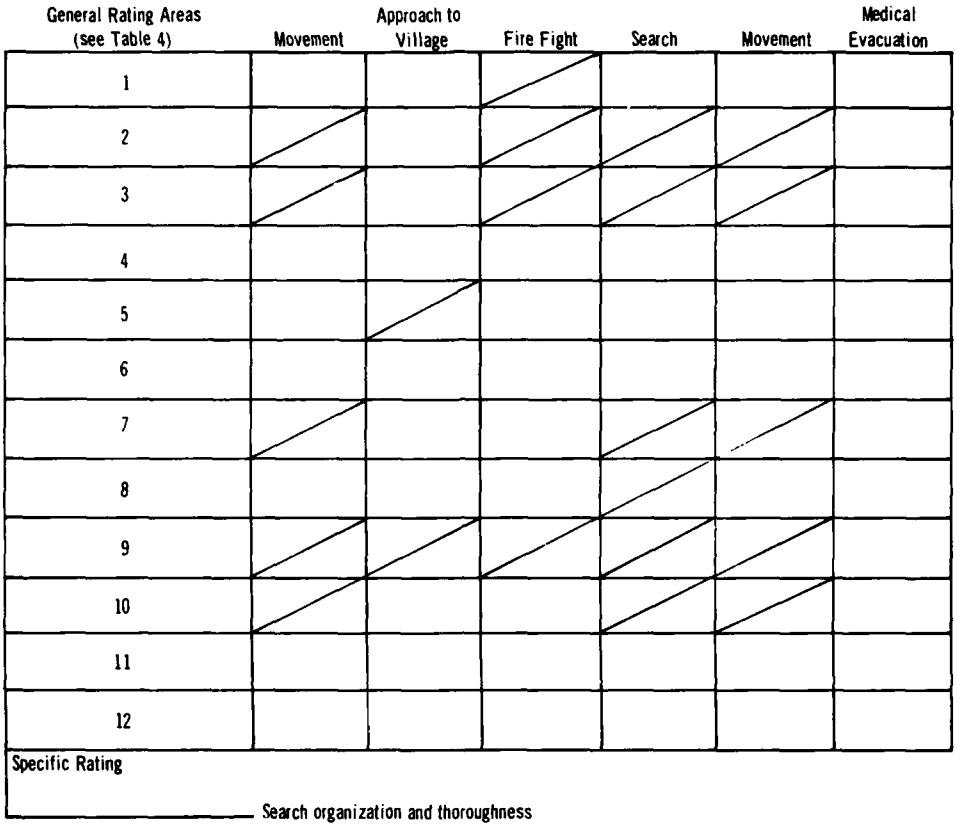

Figure 5

SUBJECTS

Each of the 32 test squads consisted of 10 men drawn from the 197th Infantry Brigade. Unfortunately, intact TOE squads were not available from this Brigade. It was found that, in general, the men furnished as squads had not trained or worked together to any appreciable extent, and their squad leaders' experience varied considerably. A number of the squad members had Vietnam combat experience.

Controllers

Controller teams of six men each were constituted from Infantry Human Research Unit personnel. One controller was required to accompany the tested squad leader, two to accompany the tested fire team leaders, one to coordinate the aggressor squad, and one to be the radio operator at the recording station. The chief controller, who also served as the platoon leader, coordinated the controllers' operations among squad and fire team leaders with the recording station.

Rating Areas Applied to Night Defense Events

General Rating Areas (see Table 4)	Defense Position	Listening Post	Enemy Attack	Reorganization
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				

Figure 6

Two controller teams were used on an alternating eight-day basis, so that individuals not working on the project during a given eight-day period were then free to perform their regular military duties. (However, the same individuals served as platoon leader/controller and radio operator on both teams.) The two teams of controllers alternated in running blocks of eight squads each, so that any team effect could be extracted through analysis of variance. Each eight-squad block included all eight of the radio distributions being examined.

The primary responsibilities of the platoon leader/controller and squad controllers were (a) to designate the initiation and termination times of critical sequences of events by a voice signal on the controller radio net, (b) to rate the performance of the squads at designated times, and (c) to assure a standardized administration of the problem from one squad to another. Controller operations were standardized by a week of training prior to the beginning of the experimental runs.

Aggressors and Auxiliaries

Personnel from the 197th also were used for aggressors and to represent the other two rifle squads of the tested platoon. Ten enlisted men were furnished

for the duration of the problem to serve these details. Of these men, two NCOs with squad leader experience represented the other two rifle squads in the platoon, furnishing the required radio traffic and firing at designated times. Their presence provided a more realistic semblance of a platoon operation. These NCOs and the remaining men who constituted the aggressor squad performed the same function throughout the experiment.

DAILY SCHEDULE OF ACTIVITIES

The daily schedule of activities is shown in Table 5. Two periods of instruction were included to provide a working level of familiarity with the AN/PRT-4 and AN/PRR-9, and to enable subjects to compensate partially for their lack of prior experience in working together.

Table 5

Daily Schedule of Activities

Hours	Activity	Area
1300 - 1330	Movement to the field	
1330 - 1350	Instruction on communications equipment	Landon Range
1350 - 1430	Practical work with communications equipment	Vicinity Landon Range
1430 - 1515	Review of current tactical doctrine on search-and-destroy, night raid and night defense	Landon Range
1515 - 1530	Orientation on search-and-destroy mission and issue of ammunition	Landon Range
1530 - 1630	Conduct of search-and-destroy mission	Area S.E. Landon Range
1630 - 1700	Return to Landon Range	
1800 - 1900	Dinner at company mess	Landon Range
2000 - 2030	Orientation on night raid mission and issue of ammunition	Landon Range
2030 - 2100	Squad check of equipment and review of procedure and plans for accomplishing mission	Landon Range
2100 - 2200	Conduct of night raid	Area S.W. Landon Range
2200 - 2230	Preparation of night defense and resupply of ammunition	Area S.W. Landon Range
2230 - 2300	Conduct of night defense	Area S.W. Landon Range
2300 - 2330	Return to post	

The communications training was necessary because most of the subjects had never seen either of the two radio components, and some had never used any radio. The training therefore included a brief introduction to radio telephone procedures, a briefing on the transmitter and receiver nomenclature, working parts, and how to use and mount it. After the briefing, which lasted approximately 20 minutes, the subjects were given 40 minutes of practical work with the equipment, which included practice in establishing and using radio nets.

Instruction in group work was provided primarily because the tested subjects lacked experience in working together as TOE squads in realistic tactical situations. The instruction included a review of squad formations; the tactical situation calling for each of the formations, to include the attack; and actions required on discovering boobytraps, encountering snipers, and other situations. This instruction was designed to standardize, to the maximum extent possible in the time available, the behavior of the tested subjects in response to the situations they would encounter, in order to minimize experimental error attributable to differences in the tactical capabilities of the subject squads.

Following the training on tactical doctrine, test subjects were oriented on their specific missions. The three phases of the overall problem were then conducted with administrative breaks for food and reorientation for the night mission.

CONDITIONS OF EXPERIMENTATION

The experimental runs were conducted at Fort Benning during a 45-day period from August to October 1967. This period at the test site is characterized by warm days and cool nights, relatively little precipitation, and, as a consequence, relatively little discomfort for experimental subjects. The daytime problem was completed prior to the hours of darkness. Degree of darkness was a consideration during the night problem, however. Since it was desired that visibility be limited to the maximum extent possible, the night problem was begun soon after the end of evening nautical twilight in order to complete both phases as nearly as possible before moonlight increased visibility to a significant extent.

During the day problem, vegetation constituted a limitation to visibility, though not to the same extent that darkness did during the night problem. Movement for the day problem began in the open, but the squad was required twice to pass through heavy underbrush where line of sight was impossible even with full sunlight. In fact, the underbrush was so heavy that nothing further was needed to canalize the movement of the experimental squad through the test situation.

The vegetation for the night problem was considerably less dense than in the day problem. Movement to the objective was through a heavy stand of mature Georgia pines which produced a high canopy with very little underbrush to impede movement. Under the canopy, visibility was severely limited even under conditions of a strong illumination from the moon. As was noted earlier, after the simulated medical evacuation, the squad was moved back into the village area for the night defense phase, in order that visibility again would be a limiting factor.

It was found during practice runs of the experimental problem that some degree of artificiality would be required in the use of the squad radio. Because of the manner in which data were being recorded, it was essential that transmissions be clear and strong. Consequently, subjects were required to leave the transmitter antenna fully extended and to transmit with the transmitter microphone held squarely in front of the mouth. This prevented test subjects from doing what they otherwise probably would have had a strong tendency to do, that is, hanging the transmitter from the harness and transmitting by speaking downward into the general vicinity of the transmitter. (It is possible that this would have been satisfactory for communication within the squad, but it would not produce reliably recordable transmissions for purposes of the experiment.) Similarly, because the built-in speaker of the AN/PRR-9 receiver did not have

sufficient volume to overcome ambient noise levels during the simulated fire fights, commands broadcast on the radio during this period simply were not heard. As this would have introduced major error variance into the time measures—a major criterion for the study—experimental subjects were directed to wear the receiver earplug at all times.

EXPERIMENTAL DESIGN

The experimental design that evolved from consideration of the variables to be controlled and those which could not be controlled led to a two-factor experimental design with eight conditions of radio distribution, two conditions of squad and fire team leader controllers, and two replicates for each treatment combination. Each controller team operated for a complete block of eight test runs (including all test conditions) before being relieved by the next controller team. Thus, the experiment was conducted in four blocks of eight experimental runs each. Each experimental squad was assigned randomly to one of the eight radio distribution conditions within a block, with the only restriction on chance being the requirement to complete a block of eight runs before beginning the next block of eight.

RESULTS

TIME MEASURES

Time measurement data can be extremely skewed as a result of some very deviant values, and appeared to have been so in the present study. Occasionally, very large times occurred; these violate the normal distribution assumptions required for the use of a parametric analysis of variance. The Kruskal-Wallis rank analysis of variance, a nonparametric analysis procedure, lacks the power of the traditional parametric analysis of variance, but is much less affected by occasional aberrant scores. For these reasons, both parametric and nonparametric analyses were performed in order to obtain the power of a parametric test and the immutability of a nonparametric test.

The significance levels attained with the parametric and with the nonparametric analyses are reported in Table 6, which also lists the radio distribution which had the lowest mean time for each measure. Summaries of the parametric analyses of variance are the corresponding tables recording individual squad time data are presented in Appendix B. The means of the various time measures, by radio distribution condition, are presented in Table 7.

In only one of the parametric analyses did radio distribution produce a significant difference in recorded times. The significant difference occurred on time 11, the time required for the squad to deploy in a night defensive position. The differences among radio distributions were significant at the $p < .01$ level.[1]

The nonparametric analysis yielded four time measures that were significant at the .05 level or better. The functions measured by these time measures are given in Table 3 as (1)communication and deployment, (2) communication under fire (twice), and (3) communication at night. From Table 7 it can be seen

[1]Analysis of difference between controller teams, which was included in the analysis to isolate and remove it from the functionally significant factors, revealed a significant difference between controller groups in two cases. The significance results from a consistent difference in judging when a given squad action had been completed.

Table 6

Results of Parametric and Nonparametric Analyses of Variance for Time Measures

Time Measure	Probability From Parametric Test	Probability From Nonparametric Test[a]	Radio Distribution With Lowest Mean
1. Boobytrap	NS	NS	2
2. Equipment	NS	NS	2
3. New Trail	NS	$p < .05$	1
4. Sniper	NS	$p < .05$	2
5. Report of Enemy Fire	NS	$p < .05$	2
6. Reaction to Fire	NS	NS	2
7. Assault	NS	NS	1
8. Approach	NS	NS	1
9. Casualty	NS	NS	2
10. Landing Zone	NS	NS	8
11. Defense	$p < .01$	$p < .01$	2
12. Listening Post	NS	NS	2

[a]Based on Kruskal-Wallis analysis of variance.

Table 7

Means of the Time Measurements

(in seconds)

Event	Radio Distribution							
	No Radio	PL and SL Transmit			PL, FTL and SL Transmit			All Transmit
	1	2	3	4	5	6	7	8
Search-and-Destroy Operation								
1. From Point 1 to PL acknowledges receipt of boobytrap info.	88	35	166	63	75	53	116	146
2. From Point 2 to PL acknowledges receipt of equipment info.	110	44	102	78	52	69	66	104
3. From PL orders squad to proceed down new trail to Point 3	24	94	62	69	109	34	43	132
4. From point man hit by sniper fire to PL acknowledges info.	67	12	67	28	43	42	98	87
5. From small enemy group opens fire to PL acknowledges message	46	16	44	21	22	33	38	48
6. From small enemy group opens fire to squad on line and returning fire	70	56	97	102	60	124	89	117
7. From SL acknowledges order to assault to squad deployed and in assault	23	44	39	24	54	48	46	62

Continued

Table 7 (Continued)

Means of the Time Measurements

(in seconds)

Event	Radio Distribution							
	No Radio	PL and SL Transmit			PL, FTL and SL Transmit			All Transmit
	1	2	3	4	5	6	7	8
Night Raid								
8. From SL acknowledges order to approach village to squad deployed in approach	245	256	281	276	362	285	446	328
9. From sniper opens fire to PL acknowledges wounded man info.	145	143	180	205	177	247	275	196
10. From PL orders squad out of village to squad deployed in LZ	827	616	483	501	676	560	666	458
Night Defense								
11. From PL orders squad to defense position to satisfactory deployment	434	179	246	284	274	437	301	314
12. From PL requests LP to LP set up	234	199	234	198	243	324	242	268
Total Mean	193	141	167	154	179	188	202	188

that the radio distribution with the lowest mean time in three of the four significant measures is Distribution 2, two-way communication between platoon leader and squad leader; the control (no radio) condition had the lowest mean time in the fourth significant measure. The mean times for the various radio distribution conditions suggest that performance was not affected to any great extent if squad members other than the leader had receivers, but that the distribution of transmitters to squad members had a negative effect.

PROFICIENCY RATINGS

In addition to time measurements, controller ratings were obtained on squad performance at significant points during each phase. The Friedman rank analysis of variance[1] was used on the sums of the controller ratings on each of the 121 separate rating situations that occurred.

Only one of the 121 rating situations—squad dispersion in defense during a night enemy attack—yielded a significant difference ($p < .05$). For this particular rating, radio Distribution 4 (two-way communication between platoon and squad leaders with receivers only for all other squad members) yielded the greatest advantage, with Distribution 2 (platoon net only) second best.

[1]This nonparametric statistic compensates for any systematic difference between the two teams of raters.

However, a yield of only one significant difference in 121 separate rating situations is well below what would be expected by chance alone. The ratings were unusually homogenous. This homogeneity indicates either an inadequacy in the rating procedure, very little comparative advantage for any of the radio combinations tested, or both.

Considering these rating data in light of the time measurement data, it appears that both of the above explanations are probable. Time measurement is a more objective criterion than is rating, so a greater incidence of statistical significance is to be expected for the time measures. However, only four of the 12 time measures yielded a statistically significant difference. It is therefore probable that (a) there was little real difference between the eight radio distributions studied, and (b) what difference did exist was detected more readily by the more objective time measures than by the proficiency ratings.

DISCUSSION

When timing the movement of communications within the platoon and the rapidity with which the squad performs certain operations, it seems logical that the addition of a radio communications capability will decrease the times required. However, the time measures obtained were not simple measures of communication time. Each time measure included the requirement for perception and/or judgment. For example, time measure 1 was the time elapsed from when the point man passed a given trail marker to the time when he perceived the presence of a boobytrap and passed this information on to the platoon leader, and the platoon leader acknowledged this information. In this way, perception and judgment were measured, as well as the effect of the radio upon communication.

However, there were variables that were not assessed or controlled in the present study which could have significantly affected the value of a given radio distribution. Leader vulnerability to enemy fire was one. The present experiment necessarily was a blank-fire exercise. The squad leaders and fire team leaders quite obviously recognized that this was the case. Anecdotal evidence obtained from the controllers at the conclusion of the experiment indicated that squad leaders and fire team leaders in no-radio and minimum radio conditions exposed themselves much more often and for longer time durations in order to obtain information and issue orders. Although the present experiment provides no factual basis for deciding either way, it was the unanimous opinion of the squad leader and fire team leader controllers that in actual combat either there would have been more leader casualties among the low density radio distributions or communications would have suffered in these distributions.

Squad leaders in the present experiment had major difficulty in handling both a platoon net and a squad net that included transmitters, since the squad leader had to wear two receivers and two earphones when transmitters were located in the squad net below him, as the squad net operated on a different frequency than the platoon net. The requirement to use two earphones further impeded the squad leader's ability to hear.

The reactions of the test squad were rigidly controlled by the orders from the platoon leader/controller. It was considered necessary to have this control to provide a comparison between the various radio distribution conditions, and because of the relative lack of experience of the squad members in working together as squads. It is conceivable that, had it not been necessary to control

the conditions of the experiment to this degree, the squads might have adapted to the increased communication capability by developing new tactics which might have improved the effectiveness of the use of the radio.

Another controller observation was that the effectiveness of the squads using the radio probably could have been improved by more training, which could well have included a trial run on a practice problem. The limited nature of the training and experience with the radio must be considered a further limitation of this study.

With the above qualifications, the major conclusions from the data were:

(1) The low density distributions of the radio are more effective, with two-way communication between the platoon leader and the squad leader being the optimal.

(2) The radio communication capability is most valuable when under enemy fire and/or in limited visibility.

(3) It makes little difference either way if members of the squad other than the squad leader have receivers. However, the distribution of the transmitter below the level of the squad leader, such as to fire team leaders, does have a negative impact.

ANNOTATED BIBLIOGRAPHY
AND
APPENDICES

ANNOTATED BIBLIOGRAPHY

Asher, J.W., Hanley, T.D., and Steer, M.D. *A Factor Analysis of Twelve Physical Measures of Voice*, Technical Report NAVTRADEVCEN 104-2-48, U.S. Naval Training Device Center, Port Washington, N.Y., February 1957.

Four of 12 investigated factors emerged as being significant for speech intelligibility. They are duration, power, power variability, and pitch variability.

Clark, Charles E., Durfee, William H., Hazell, Joseph W., and Yudowitch, Kenneth L. *Effectiveness of Miniature Radios in Small Infantry Units*, Technical Memorandum ORO-T-338, Operations Research Office, The Johns Hopkins University, Chevy Chase, Md., May 1956.

(1) Under noise of small arms fire, radio allowed for better communications. *However an inoperative radio lowered the intelligibility of normally spoken orders significantly.*

(2) Wind did not significantly affect radio communication. Wind did affect shouted commands.

(3) Messages transmitted by finger tapping Morse code on the microphone were understood by 85%, 97%, and 98% of the men the first, second and third time transmitted respectively.

(4) There was less of a lull in firing while the squad listened to orders by radio than by shouting.

(5) When all the squad members had receivers, a message was radio transmitted to them in five seconds. The same message shouted took one minute.

(6) Radio achieved 75% comprehension; runners 95%.

(7) One advantage of radio over relayed signal (hand, touch or otherwise) is that there is only one source of error rather than each man in the relay chain being an error source.

(8) Radio avoids "bunching" on night patrol.

(9) Two statements were required to assume accuracy when the recipient could reply; three were required when he could not reply.

Doty, L., Hanley, T.D., and Steer, M.D. *A Study of Type and Frequency of Communication Messages Aboard Naval Vessels*, Technical Report SPECDEVCEN 104-2-42, Special Devices Center, Port Washington, N.Y., April 1955.

During a naval operation, 30% of the messages transmitted were irrelevant to the operation.

Draegert, G.L. and Hanley, T.D. "Relationships between Voice Variables and Speech Intelligibility in High Level Noise," *Speech Monogr.*, vol. 18, November 1951, pp. 272-278.

Of 15 voice variables examined during noisy conditions, vocal intensity and syllable duration were the most important for intelligibility.

Egan, J.P., Miller, J., Stein, M.I., Thompson, G.G., and Waterman, T.H. *Studies on the Effect of Noise and Speech Communications*, Publication Board No. 22907, Department of Commerce, Washington, 1943.

The report contains tables of percent syllable articulation of speech, signal to noise ratio for white noise, 400 cps and 150 cps tone spikes. For the worst case, white noise, a 6 db. signal to noise ratio was sufficient for intelligibility of connected discourse. Articulation asymtotes to about 90% at about 30 db. signal to noise ratio.

Hanley, T.D. and Draegert, G.L. "Effect of Level of Distracting Noise upon Speaking Rate, Duration and Intensity," *J. Speech Hearing Disord.*, vol. 14, 1949, pp. 363-368.

As noise levels increased, subjects automatically decreased their words per minute, increased percent speech time, increased syllable duration, increased intensity, and judged noise to be louder.

Harris, J.S. *Voice Communication: Effect of Stress Conditions on Speaker Intelligibility*, Technical Report SPECDEVCEN 104-2-10, Special Devices Center, Port Washington, N.Y., September 1948.

Under stress, variability of intensity increases while average syllable intensity and duration decrease.

Kelly, J.C. *Syllable Duration and Intensity Related to Intelligibility*, Technical Report SPECDEVCEN 104-2-15, Special Devices Center, Port Washington, N.Y., July 1949.

People can be taught to increase their syllable duration and speech intensity, and, therefore, their intelligibility.

Kelly, J.C. and Steer, M.D. "Intelligibility Testing in Three Conditions Involving Masking Noise," *J. Speech Hearing Disord.*, vol. 14, 1949, pp. 369-372.

The authors investigated constant signal to noise ratios at various noise levels and found no difference as a function of absolute noise level.

Leavitt, H.J. *Managerial Psychology*, University of Chicago Press, Chicago, 1958.

Of five communications nets examined (free, circle, chain, y, and wheel [x]), the free network was generally the most versatile since the leader was chosen according to the problem. The wheel was next best. The center man was always the leader; therefore no preliminary messages were required to establish a leader. For very simple tasks, the wheel was best.

Martin, Frederick N., Bailey, H.A.T., Jr., and Pappas, James J. "The Effect of Central Masking on Thresholds for Speech," *J. Auditory Res.*, vol. 5, 1965, pp. 293-296.

Central masking is defined as occurring when a subthreshold monaural stimulation raises the absolute sound threshold in the contralateral ear. A gradual increase was obtained which required a correction of 4 to 8 db.

Appendix A

CONTROLLER BRIEFING PAPERS

Section I—EXPERIMENT DESCRIPTION

The purpose of this field study is to examine the effect of general distributions of individual radios upon squad performance. There are two radio nets in this examination. The platoon net is between platoon and squad leaders. The squad net is from squad leader on down. In addition, the controllers are on a separate net. The radio distributions to be examined are listed below:

1. Control group - no squad radio.
2. Two-way communication between platoon and squad leaders.
3. Two-way communication down to squad leaders with receivers for fire team leaders.
4. Two-way communication down to squad leaders with receivers for everyone else.
5. Two-way communication down to fire team leaders.
6. Two-way communication down to fire team leaders with receivers for one member of each buddy pair.
7. Two-way communication down to fire team leaders with receivers for everyone else.
8. Two-way communication for everybody.

Two types of measures will be taken: (1) elapsed time and (2) proficiency ratings. The controllers will be responsible for designating occurrences (elapsed time will be measured from the tape recordings of the radio conversations) and making independent ratings of the squad. The proficiency scale will be read to the controllers over the controllers' radio net. The controllers will record each rating on a separate sheet of paper without consulting each other.

Section II—EXPERIMENT CALENDAR

	Monday	Tuesday	Wednesday	Thursday	Friday
Date SEP.					Team A 1
Run					2
Date		5	6	7	8
Run		4	7	5	1
Date	11	12	13	Team B 14	15
Run	8	3	6	1	8
Date	18	19	20	21	22
Run	3	6	2	4	7
Date	25	Team A 26	27	28	29
Run	5	7	5	4	2

	Monday	Tuesday	Wednesday	Thursday	Friday
Date OCT.	2	3	4	5	Team B 6
Run	3	6	8	1	6
Date	9	10	11	12	13
Run	3	1	8	5	7
Date	16	17			
Run	4	2			

Section III—SCENARIOS

Day Search-and-Destroy Operation

You are operating on a decentralized company operation. The other platoons in your company are operating at a minimum of 1,500 meters from your position. You are to conduct a search-and-destroy mission in your assigned area. The enemy in the area is believed to consist of squad-size elements defending small supply bases. The terrain in the area of operations is level with a few small streams and the vegetation varies from light to heavily wooded. Artillery support is available but must be requested through the company.

The squads are made up of 10 men. The second and third squads each have one machinegun attached. The first squad has no attachments. Each squad has two M79 grenadiers. (These men carry the M14 like all other members of the squad, but are so designated and will react as grenadiers when called for by the platoon leader or the squad leader.)

The squad is acting as the point squad for the platoon and is moving southeast from a point east of Landon Range. The platoon leader has instructed the squad leader to remain inside the tree line as far as possible and still guide on the open area to the right. The platoon is moving in a file formation. The squad employs two point men 25 meters to the front and one man on flank security on the left side of the squad who maintains visual contact with the squad. No security element is employed on the right flank of the formation which is open terrain. The second and third squads follow in that order. During movement, noise discipline is to be maintained as much as possible. Each man is to keep a minimum of 10 meters behind the man to his front, and there should be at least 10 meters between the two fire teams. The platoon leader will position himself where he feels he can best observe and control his squads.

Prior to moving out, the squad members and especially the point and flank security men are instructed to be particularly watchful for boobytraps. In the event a boobytrap is detonated, everybody is to immediately get down and await further orders. If anyone spots any such device, he is to stop the column and get the word back to the platoon leader.

The platoon leader will instruct the men to search the immediate area for more boobytraps and to clearly mark all that are found. The platoon will then regroup and continue movement in the same general direction, again following the edge of the tree line and employing the same security measures. No casualties will be assessed upon initial contact with the boobytraps which will be positioned in three locations at a point 200 meters from the starting point along the route of march.

After proceeding another 100 meters, an item of enemy equipment is detected, the column is halted, and the platoon leader informed. The squad

leader is instructed to check it out and inform the platoon leader of its consequence. The squad leader informs the platoon leader that it appears to be some ammunition in boxes. The platoon leader tells the squad leader to mark it and leave it because it might be boobytrapped. The platoon leader informs the company commander of its exact location so a demolition team can be sent in to destroy it.

The platoon leader then directs the squad leader to move out in a squad column formation with fire teams abreast and to move southeast, guiding on this new trail. One fire team is on each side of the trail and there is one flank security man on each side of the formation. The flank security again maintains visual contact with the main body of the squad. Two point men are 15 to 20 meters in front of the rest of the squad. After moving 25 meters down the trail, the squad is brought under fire by a concealed sniper and the lead point man gets hit. The other point man takes cover and returns the fire. The squad leader directs the fire team leaders to return the sniper fire with M79 fire. (In this case, the men designated as M79 grenadiers will return the fire. The second point man and the M79 grenadiers should be the only people firing at this time.) The sniper then withdraws rapidly up the trail. The squad leader moves up to check on the situation and then reports to the platoon leader who tells him to follow the new trail. The squad leader also requests that the platoon medic be sent up for his casualty. When the squad moves out, the casualty is left with the medic and the platoon leader calls the company commander to request a med-evac.

As the squad advances along the trail, they are taken under fire by a small group of enemy. (There will actually be three aggressors. An estimate of the situation should include a figure for enemy strength. This should be given to the platoon leader by the squad leader.) When the squad receives the enemy fire, the squad leader deploys his men on line and immediately returns the fire. When he informs the platoon leader of the situation, he is instructed to remain in position and lay down a base of fire for the second and third squads who are maneuvering around to the right flank to assault the enemy from that direction. However, when the second and third squads get into position to start their assault and begin firing, they are pinned down by a heavy volume of fire, including machine-gun fire. It is now evident that the lead squad initially made contact with the flank of an enemy defensive position and the second and third squads are now directly in front of the position. The platoon leader informs the squad leader of this situation and instructs him to assault the enemy from his position while the second and third squads give him support.

As soon as the enemy realize they are being assaulted from their flank, they withdraw, covering their movement with scattered rifle fire from a small delaying force. The assault squad continues to return the fire until the enemy have stopped firing. At this time, the platoon leader informs the squad leader that the second and third squads are moving into position around the area suspected to be a small supply base and that he is to search the area with his squad, checking for hidden boobytraps and enemy equipment and supplies. The squad leader informs the platoon leader of any of these items he might find. As this equipment might be boobytrapped, the squad leader informs his men only to mark what they find and to handle none of it. There are several boobytraps in the area the squad must watch for. The squad is directed not to cross the creek behind the supply base during the search. The aggressor force initiates a counterattack during the search operation, but this lasts only two or three minutes and is repelled. The search continues.

Upon completion of the search, the fire team leaders report to the squad leader and he, in turn, reports to the platoon leader. After all reports are in, this phase of the problem terminates.

Night Raid

Reliable intelligence has been received to indicate the enemy is using a small village in the jungle as a rest and resupply point. Informants report that a small group of men usually comes into the village after dark, stays there overnight, and leaves before dawn. The platoon has been given the mission of conducting a night raid on this village to kill or capture the enemy. The platoon has made a clandestine early morning entry into the area and during daylight has moved to within 1,000 meters of the village without being detected. Small recon patrols were sent out to look for suitable night approaches while the platoon remained in a concealed location.

The platoon leader now orients his platoon and assigns specific missions to each squad. The orientation will include the route of march, the location of the village, and the point at which the first squad will remain while the second and third squads move into blocking positions. The orientation will also include a probable LZ and a route to and from the LZ to be used in the event a med-evac is required. The open area near the village will be mentioned and shown as a possible area for a night defensive position.

The first squad is given the mission of leading the platoon in its approach to the enemy village and then holding in position outside the village while the two other squads maneuver into blocking positions on the far side of the village.

During movement, the first squad will be in a file formation, with the second and third squads in file behind the first squad. Two point men will lead the squad, maintaining a 20-meter distance if visibility permits. No flank security will be used during night movement. Men will maintain the maximum amount of dispersion allowed by visibility and terrain. The platoon will be guiding on roads and trails during this movement. The platoon leader and lead squad leader will have reconned the area during daylight hours. Maximum light and noise discipline will be enforced. The men will be instructed not to fire unless they receive enemy fire, in which case they will immediately return the fire.

Upon reaching the fork at the base of the southbound trail, the first squad will hold in position and maintain local security. The squad leader controller will ensure that the squad leader does not allow his men to pass this point. The squad leader and one fire team leader will recon forward to find their line of deployment which has been designated in the operation order. The squad leader controller will accompany this recon. When the squad leader returns to his squad, he will be instructed to move the squad to the clearing from which he has just returned and to deploy on line. The platoon leader also will instruct the second and third squads to move into their blocking positions. When the first squad leader is in position and ready to assault, he will notify the platoon leader. When the platoon leader notifies the first squad leader that the other two squads are in position, he will move his squad up and attempt to make a surprise assault on the village.

As the assault begins, an enemy outpost will discover them and fire to alert the enemy in the village. The enemy in the village will engage the first squad in a brief fire fight and then withdraw into the jungle. At the beginning of the assault, the first squad will not know they are going to be detected; so when they are fired upon, they will have to act on direction from the squad leader,

who will communicate through his fire team leaders. The squad leader will have his squad take cover and immediately return the fire. According to intelligence information there are no friendly people in the village. Thus, the friendly troops are not concerned with identifying targets inside the village once the attack is initiated.

The aggressor forces will all be inside the village, with the exception of a two-man outpost that will warn the village of the squad's approach. As soon as the two men fire several rounds each, they will withdraw into the village. As the advancing forces reach a predetermined point, the aggressors will pull back into the jungle, covering their movement with sporadic firing.

The squad leader will then move his men into the village, but they will not proceed past the boundaries of the village in pursuit of the enemy. After driving the enemy out, the squad will conduct a quick search while maintaining a hasty defense around the inside of the village. The men will not enter any structures during the search, but will clear them with grenades. (Practice grenades will be supplied for this purpose.) No hidden VC are detected. There are, however, several boobytraps in the area and several pieces of equipment. Upon finding any such equipment, the squad leader should have it marked and report its presence to the platoon leader. The search should be conducted very quickly and the platoon leader should get his men out of the village after 10 minutes as the VC they ran off might return with more troops.

During the fire fight, one man in the first squad will be declared a casualty. After the enemy have fled from the village, the casualty and the man closest to him will be told by a controller that he is seriously injured and requires immediate medical attention and med-evac. This man will in turn inform his fire team leader, who will contact his squad leader by radio and inform him of the casualty. The squad leader will then call the platoon leader and request the med-evac. By then the search of the village will be complete.

The platoon leader sends the second and third squads to a nearby clearing to set up security around an LZ. This is the clearing that was noted during the orientation and the squads are told to use the predetermined route to this LZ. The first squad moves its casualty to the clearing for a simulated evacuation, also using the predetermined route. There is no more enemy contact at this time. The simulated evacuation will end this phase of the operation.

Night Defense

After the simulated med-evac, the platoon is directed to move back to the vicinity of the enemy village. Because they had to leave the village once to evacuate the casualty, the platoon leader decides against returning to the village itself for the night. He informs the squad leaders that they will return to the clearing near the village to set up a platoon perimeter defense for the rest of the night and that they will complete the search of the village in the morning. The platoon is directed to move into the night defense positions silently so the enemy will not know their exact location. The platoon moves back to the clearing near the village and the platoon leader assigns portions of the perimeter to the three squads to organize and defend.

Movement from the evacuation point back to the defensive position will again be in squad file formation. Two-man point security will be utilized and strict silence must be maintained.

Upon reaching the clearing, the column is halted and the squad leader and the two point men move forward for a quick check of the area and to locate the section of the perimeter assigned to the first squad by the platoon leader. When

this has been done, the squad leader calls back to the platoon leader and the platoon moves forward. (All areas of responsibility will be designated on the clock system. Movement into the area will be from 6 o'clock to 12 o'clock.) The squad leader will meet the elements of his squad at 6 o'clock and move them into their assigned positions as quickly and quietly as possible. There will be as little movement as possible after arriving in the area and setting up the perimeter.

Shortly after getting into position, the platoon leader contacts the first squad leader and directs him to place a three-man listening post out on a trail leading into their position and to set up two-man positions in his portion of the perimeter with the rest of the men. The three-man listening post is directed to proceed up the trail about 35 meters to a point where the trail forms a "Y" and take up a position affording them good concealment and observation of the trail. The squad leader is instructed to inform the platoon leader when the LP is in position. The listening post is sent out and the men are quickly and silently put into hasty defense positions (NO DIGGING IN). The listening post is directed to fire on any enemy they observe. They are to get back to the perimeter as soon as possible after any contact is made. They are not to become decisively engaged. The men in the perimeter are instructed to return any fire they receive with grenades, semiautomatic rifle fire, and M79 fire only.

After a wait of about 15 minutes, the enemy will slowly approach the listening post along the sides of the trail. Upon being discovered by the listening post, the enemy fires on them. The listening post returns the fire, throws grenades, and withdraws to the perimeter.

The enemy now moves in closer to the squad, opens fire, and starts an attack. The squad should now be keeping the platoon leader informed on the attack while attempting to beat the enemy off. After a period of 10 minutes, during which the enemy attempts to probe different parts of the perimeter, the platoon leader is able to bring in effective artillery fire which forces the enemy to break contact and withdraw. The squad now hastily reorganizes, and redistributes ammunition. When these actions have been taken, the problem is terminated.

Section IV—CONTROL PLAN

Sequence of Events and Measurements

The platoon leader/controller and the squad leader and fire team leader controllers will rate the entire squad on each event listed below. The rater's decision will be based on the portion of the squad he can observe at any given time. All times will be given in minutes (whole or fractions), and all ratings will be made on a five-point scale: 1 - Excellent, 2 - Good, 3 - Average, 4 - Poor, and 5 - Inadequate.

EVENT	CONTROLLER	FUNCTION
Search-and-Destroy Operation		
Movement and Boobytraps	Alfa fire team (AFT)	1. Designate time point man passes point 1 in booby-trap area.

EVENT	CONTROLLER	FUNCTION
Search-and-Destroy Operation		
Movement and Boobytraps (Continued)	Platoon leader (PL)	2. Designate time platoon leader acknowledges receipt of message concerning presence of boobytraps.
	PL	3. Request recorder to read rating scale.
	Recorder	4. Read rating scale to controllers.
	AFT, Bravo fire team (BFT) and squad leader (SL)	5. Rate proficiency of entire squad on a five-point scale. Ratings will be made on several factors.
Enemy Equipment	AFT	6. Designate time point man passes point 2 in equipment-find area.
	PL	7. Designate time platoon leader acknowledges receipt of message concerning enemy equipment.
	PL	8. Designate time platoon leader gives order to proceed down new trail.
	BFT	9. Designate time last man in squad has passed point 3 along trail.
	PL	10. Request recorder to read rating scale.
	Recorder	11. Read rating scale to controllers.
	AFT, BFT & SL	12. Rate proficiency of entire squad.
Sniper	AFT	13. Designate time sniper opens fire and designate point man to be a non-walking casualty.
	PL	14. Designate time platoon leader acknowledges receipt of message concerning sniper and wounded man.
	PL	15. Request recorder to read rating scale.
	Recorder	16. Read rating scale to controllers.

EVENT	CONTROLLER	FUNCTION
Search-and-Destroy Operation		
Sniper (Continued)	AFT, BFT & SL	17. Rate proficiency of entire squad.
Small Group of Enemy	AFT	18. Designate time small group opens fire.
	PL	19. Designate time platoon leader acknowledges receipt of message concerning direction and size of enemy.
	SL	20. Designate time squad is on line and returning enemy fire.
	PL	21. Request recorder to read rating scale.
	Recorder	22. Read rating scale to controllers.
	AFT, BFT & SL	23. Rate entire squad on proficiency.
Assault	SL	24. Designate time squad leader acknowledges orders to assault.
	SL	25. Designate time squad is fully deployed and in assault.
	PL	26. Request recorder to read rating scale.
	Recorder	27. Read rating scale to controllers.
	AFT, BFT & SL	28. Rate entire squad on proficiency.
Search	PL	29. Request recorder to read rating scale.
	Recorder	30. Read rating scale to controllers.
	AFT, BFT & SL	31. Rate entire squad on proficiency.
Night Raid		
Approach to Village	SL	32. Designate time squad leader acknowledges receipt of order to approach village (after recon patrol).

EVENT	CONTROLLER	FUNCTION
Night Raid		
Approach to Village (Continued)	SL	33. Designate when squad is deployed and approaching village.
	PL	34. Request recorder to read rating scale for proficiency and stealth of squad movement and deployment.
	Recorder	35. Read rating scale.
	AFT, BFT & SL	36. Rate entire squad.
Enemy Outpost, Fire Fight, and Village Search	BFT	37. Designate one rifleman to be non-walking wounded and inform nearest man to wounded man of that designation.
	PL	38. Designate time platoon leader acknowledges receipt of message concerning wounded man.
	PL	39. Request recorder to read rating scale.
	Recorder	40. Read rating scale for enemy outpost, fire fight and village search.
	AFT, BFT & SL	41. Rate entire squad.
Med-Evac	PL	42. Designate time platoon leader orders squad out of village to LZ.
	SL	43. Designate time squad is satisfactorily deployed in LZ.
	PL	44. Request recorder read rating scale for med-evac.
	Recorder	45. Read rating scale.
	AFT, BFT & SL	46. Record ratings.
Night Defense		
Defense Position	Recorder	47. Inform platoon leader/ controller that equipment is ready for night defense.
	PL	48. Designate time platoon leader orders squad to defense position.

EVENT	CONTROLLER	FUNCTION
Night Defense		
Defense Position (Continued)	SL	49. Designate time squad is satisfactorily deployed in defense position excluding setting up of listening post.
	PL	50. Request recorder read rating scale for deployment to defense position.
	Recorder	51. Read rating scale.
	AFT, BFT & SL	52. Rate performance of entire squad.
Listening Post and Two-man Positions	PL	53. Designate time platoon leader requests setting up of listening post and two-man positions.
	SL	54. Designate time squad and listening post in position.
	PL	55. Request recorder read rating scale for listening post and two-man positions.
	Recorder	56. Read rating scale.
	AFT, BFT & SL	57. Record ratings.
Enemy Attack	PL	58. Designate time platoon leader is informed of enemy in area.
	PL	59. Designate time enemy opens fire (could be simultaneous with 57).
	PL	60. Request recorder read rating scale for enemy attack and listening post withdrawal.
	Recorder	61. Read rating scale.
	AFT, BFT & SL	62. Record rating scale.
Reorganization	PL	63. Request recorder read rating scale for reorganization.
	Recorder	64. Read rating scale.
	AFT, BFT & SL	65. Record rating scale.

Training Program of Controller and Aggressor Personnel

1. 25 and 28 August
   a. Field operations from 0830 to 1600 hours.
   b. Aggressor squad in opposition except for two members selected as squad simulators.
   c. Controller Teams A and B will alternate by days in acting as controllers and as platoon, squad and fire team leaders.
   d. Controllers on both teams will endeavor to standardize measurement points.
2. 29 to 31 August
   a. Field operations from 1300 to 1630 and 2000 to 2330 hours.
   b. Same as training period above except conducted at night.

Appendix B

TIME DATA AND ANALYSES

Table B-1

Time 1 (Boobytrap) Measures and Analysis of Variance
(seconds)

Controller Group	Set	Radio Distribution								Group Mean
		1	2	3	4	5	6	7	8	
A	1	52	22	27	43	93	54	18	188	
	3	96	36	478	90	62	64	273	195	
	Mean	74.0	29.0	252.5	66.5	127.5	59.0	145.5	191.5	111.9
B	2	77	47	50	53	104	16	122	90	
	4	127	35	110	67	40	77	53	113	
	Mean	102.0	41.0	80.0	60.0	72.0	46.5	87.5	101.5	73.8
Condition Mean		88.0	35.0	166.5	63.2	74.8	52.8	116.5	146.5	92.9

Source of Variation	*df*	*MS*	*F*	*p*
Radio	7	8,575.50	<1	*NS*
Controller	1	11,628.12	1.26	*NS*
Radio x Controller	7	4,392.70	<1	*NS*
Within Groups	16	9,169.50		

Table B-2

Time 2 (Equipment) Measures and Analysis of Variance
(seconds)

Controller Group	Set	Radio Distribution								Group Mean
		1	2	3	4	5	6	7	8	
A	1	60	52	73	163	50	62	56	78	
	3	50	29	117	35	62	69	108	68	
	Mean	55.0	40.5	95.0	99.0	56.0	65.5	82.0	73.0	70.8
B	2	135	48	109	49	69	56	29	178	
	4	195	45	109	67	29	90	69	94	
	Mean	165.0	46.5	109.0	58.0	49.0	73.0	49.0	136.0	85.7
Condition Mean		110.0	43.5	102.5	78.5	52.5	69.2	65.5	104.5	78.2

Source of Variation	*df*	*MS*	*F*	*p*
Radio	7	2,500.25	2.15	*NS*
Controller	1	1,785.03	1.53	*NS*
Radio x Controller	7	2,497.32	2.14	*NS*
Within Groups	16	1,165.34		

Table B-3

Time 3 (New Trail) Measures and Analysis of Variance

(seconds)

Controller Group	Set	Radio Distribution								Group Mean
		1	2	3	4	5	6	7	8	
A	1	4	137	79	37	49	15	20	118	
	3	61	122	39	66	229	9	24	166	
	Mean	32.5	129.5	59.0	51.5	138.5	12.0	22.0	142.0	73.4
B	2	20	21	117	100	81	25	23	127	
	4	13	94	11	74	78	89	104	116	
	Mean	16.5	57.5	64.0	87.0	79.5	57.0	63.5	121.5	68.3
Condition Mean		24.5	93.5	61.5	69.0	109.0	34.5	42.8	131.8	70.8

Source of Variation	*df*	*MS*	*F*	*p*
Radio	7	5,729.41	2.65	*NS*
Controller	1	204.92	< 1	*NS*
Radio x Controller	7	2,024.12	.94	*NS*
Within Groups	16	2,159.66		

Table B-4

Time 4 (Sniper) Measures and Analysis of Variance

(seconds)

Controller Group	Set	Radio Distribution								Group Mean
		1	2	3	4	5	6	7	8	
A	1	30	−19[a]	13	41	42	29	47	82	
	3	46	10	82	36	13	81	59	117	
	Mean	38.0	− 4.5	47.5	38.5	27.5	55.0	53.0	99.5	44.3
B	2	162	46	52	16	103	27	231	89	
	4	31	10	121	17	14	33	53	59	
	Mean	96.5	28.0	86.5	16.5	58.5	30.5	142.0	74.0	66.5
Condition Mean		67.2	11.8	67.0	27.5	43.0	42.5	97.5	86.8	55.4

Source of Variation	*df*	*MS*	*F*	*p*
Radio	7	3,448.08	148	*NS*
Controller	1	3,938.37	1.69	*NS*
Radio x Controller	7	1,814.63	< 1	*NS*
Within Groups	16	2,329.91		

[a]One point man saw the sniper and alerted the platoon leader 19 seconds before the sniper fired.

Table B-5

Time 5 (Report of Enemy Fire) Measures and Analysis of Variance

(seconds)

Controller Group	Set	Radio Distribution								Group Mean
		1	2	3	4	5	6	7	8	
A	1	66	25	59	22	32	41	15	132	
	3	60	20	62	20	26	11	21	34	
	Mean	63.0	22.5	60.5	27.0	29.0	26.0	18.0	83.0	40.4
B	2	34	5	17	16	15	32	90	16	
	4	26	13	38	27	14	48	28	11	
	Mean	30.0	9.0	27.5	21.5	14.5	40.0	59.0	13.5	26.2
Condition Mean		46.5	15.8	44.0	21.2	21.8	33.0	38.5	48.2	33.6

Source of Variation	*df*	*MS*	*F*	*p*
Radio	7	642.93	1.33	*NS*
Controller	1	1,458.00	3.02	*NS*
Radio x Controller	7	1,117.14	2.31	*NS*
Within Groups	16	483.31		

Table B-6

Time 6 (Reaction to Fire) Measures and Analysis of Variance

(seconds)

Controller Group	Set	Radio Distribution								Group Mean
		1	2	3	4	5	6	7	8	
A	1	100	47	127	121	77	52	57	103	
	3	26	43	31	10	28	69	34	31	
	Mean	63.0	45.0	79.0	65.5	52.5	60.5	45.5	67.0	59.8
B	2	47	47	80	132	65	94	198	145	
	4	107	89	149	145	69	280	68	189	
	Mean	77.0	68.0	114.5	138.5	67.0	187.0	133.0	167.0	119.0
Condition Mean		57.5	56.5	96.8	202.0	59.8	123.8	89.2	117.0	89.4

Source of Variation	*df*	*MS*	*F*	*p*
Radio	7	2,567.07	<1	*NS*
Controller	1	28,084.50	9.06	$p < .01$
Radio x Controller	7	1,871.21	<1	*NS*
Within Groups	16	3,099.19		

Table B-7

Time 7 (Assault) Measures and Analysis of Variance
(seconds)

Controller Group	Set	Radio Distribution								Group Mean
		1	2	3	4	5	6	7	8	
A	1	8	38	118	2	130	30	85	88	
	3	26	84	13	76	49	16	76	35	
	Mean	17.0	61.0	65.5	39.0	89.5	23.0	80.5	61.5	54.6
B	2	51	12	10	4	10	43	10	35	
	4	8	44	16	13	26	103	14	91	
	Mean	29.5	28.0	13.0	8.5	18.0	73.0	12.0	63.0	30.6
Condition Mean		23.2	44.5	39.2	23.8	53.8	48.0	46.2	62.2	42.6

Source of Variation	*df*	*MS*	*F*	*p*
Radio	7	714.43	<1	*NS*
Controller	1	4,608.00	3.82	*NS*
Radio x Controller	7	1,807.36	1.50	*NS*
Within Groups	16	1,205.81		

Table B-8

Time 8 (Approach to Village) Measures and Analysis of Variance
(seconds)

Controller Group	Set	Radio Distribution								Group Mean
		1	2	3	4	5	6	7	8	
A	1	245[a]	384	136	229	542	164	362	371	
	3	291	192	336	330	312	380	747	285	
	Mean	268.0	288.0	236.0	279.5	427.0	272.0	559.5	328.0	
B	2	182	271	196	207	329	233	281	344	
	4	261	175	455	338	264	362	396	314	
	Mean	221.5	223.0	325.5	272.5	296.5	297.5	338.5	329.0	288.0
Condition Mean		244.8	255.5	280.8	276.0	361.8	284.8	446.5	328.5	309.8

Source of Variation	*df*	*MS*	*F*	*p*
Radio	7	18,016.70	1.20	*NS*
Controller	1	15,225.12	1.02	*NS*
Radio x Controller	7	9,079.84	<1	*NS*
Within Groups	16	14,970.25		

[a]Missing data estimated by using the mean of the other three sets.

Table B-9

Time 9 (Casualty) Measures and Analysis of Variance

(seconds)

Controller Group	Set	Radio Distribution								Group Mean
		1	2	3	4	5	6	7	8	
A	1	76	106	268	114	141	152	399	283	
	3	83	71	47	150	252	349	148	72	
	Mean	79.5	88.5	157.5	132.0	196.5	250.5	273.5	177.5	169.4
B	2	351	252	332	500	167	121	339	110	
	4	71	143[a]	75	56	149	365	213	320	
	Mean	211.0	197.5	203.5	278.0	158.0	243.0	276.0	215.0	222.8
Condition Mean		145.2	143.0	180.5	205.0	177.2	246.8	274.8	196.2	196.1

Source of Variation	*df*	*MS*	*F*	*p*
Radio	7	8,476.85	<1	*NS*
Controller	1	22,737.78	1.06	*NS*
Radio x Controller	7	4,688.35	<1	*NS*
Within Groups	16	21,355.16		

[a]Missing data estimated by using the mean of the other three sets.

Table B-10

Time 10 (LZ) Measures and Analysis of Variance

(seconds)

Controller Group	Set	Radio Distribution								Group Mean
		1	2	3	4	5	6	7	8	
A	1	427	632	232	380	770	545	539	356	
	3	532	445	586	517	726	612	750	307	
	Mean	479.5	538.5	409.0	448.5	748.0	578.5	644.5	331.5	522.2
B	2	891	719	362	414	580	502	730	491	
	4	1,457	668	752	692	629	581	647	659	
	Mean	1,174.0	693.5	557.0	553.0	604.5	541.5	688.5	575.0	673.4
Condition Mean		826.8	616.0	483.0	500.8	676.2	560.0	666.5	453.2	597.8

Source of Variation	*df*	*MS*	*F*	*p*
Radio	7	62,025.55	2.36	*NS*
Controller	1	182,710.12	6.96	.01 *p* .05
Radio x Controller	7	62,808.41	2.36	*NS*
Within Groups	16	26,235.06		

Table B-11

Time 11 (Defense) Measures and Analysis of Variance

(seconds)

Controller Group	Set	Radio Distribution								Group Mean
		1	2	3	4	5	6	7	8	
A	1	278	257	199	291	419	403	373	282	
	3	478	149	248	314	218	425	269	255	
	Mean	378.0	203.0	223.5	302.5	318.5	414.0	321.0	268.5	303.6
B	2	478	113	208	273	257	536	338	463	
	4	500	197	329	258	202	386	223	257	
	Mean	489.0	155.0	268.5	265.5	229.5	461.0	280.5	360.0	313.6
Condition Mean		433.5	179.0	246.0	284.0	274.0	437.5	300.8	314.2	308.6

Source of Variation	*df*	*MS*	*F*	*p*
Radio	7	31,322.00	4.76	$p<.01$
Controller	1	800.00	<1	*NS*
Radio x Controller	7	5,344.50	<1	*NS*
Within Groups	16	6,581.75		

Table B-12

Time 12 (LP) Measures and Analysis of Variance

(seconds)

Controller Group	Set	Radio Distribution								Group Mean
		1	2	3	4	5	6	7	8	
A	1	125	177	304	246	301	223	480	401	
	3	300	241	239	136	234	372	151	244	
	Mean	212.5	209.0	271.5	191.0	267.5	297.5	315.5	322.5	260.9
B	2	283	210	210	212	286	248	154	271	
	4	228	169	185	198	150	455	184	156	
	Mean	255.5	189.5	197.5	205.0	218.0	351.5	169.0	213.5	224.9
Condition Mean		234.0	199.2	234.5	198.0	242.8	324.5	242.2	268.0	242.9

Source of Variation	*df*	*MS*	*F*	*p*
Radio	7	6,491.50	<1	*NS*
Controller	1	10,332.03	1.13	*NS*
Radio x Controller	7	5,182.67	<1	*NS*
Within Groups	16	9,113.22		

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13. ABSTRACT

To determine the optimum radio distribution within the infantry squad, a three-phase squad tactical problem was conducted to test seven distributions of the radio and a no-radio control condition. Measures included times required to accomplish specific actions and the rated effectiveness of the squad in accomplishing its assigned tasks. The radio provided a significant advantage under enemy fire and/or limited visibility. The optimal radio distribution in the simulation was two-way communication between platoon leader and squad leader. Additional receivers below the level of the squad leader neither helped nor hindered proficiency, but additional transmitters below this level deteriorated overall performance. The data on proficiency ratings were generally not significant.

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