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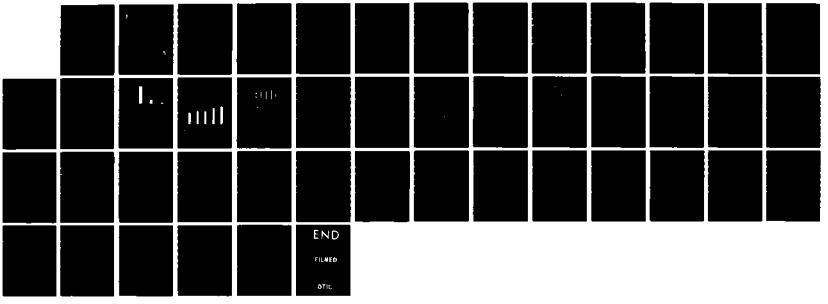

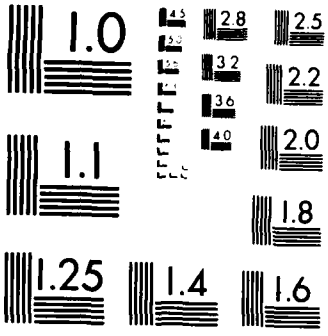

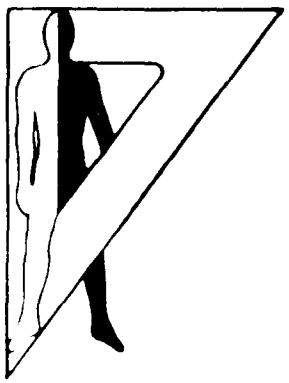

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Technical Note 14-84

U.S. ARMY HUMAN ENGINEERING LABORATORY COMMUNICATIONS SURVEY-A PILOT STUDY (HELCOMS-PS)

Russell M. Phelps
George A. Kupets, Sr.

November 1984

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U. S. ARMY HUMAN ENGINEERING LABORATORY
Aberdeen Proving Ground, Maryland

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Voice radio traffic was collected at National Training Center exercises in Ft. Irwin, CA. The traffic consisted of five one-hour samples covering peak-period traffic on several command nets. This traffic underwent a detailed exploratory analysis and identified several human performance issues which will be subjected to further evaluation in a follow-on effort. Sample issues covered in this report include expected wait time, transmission rates, station utilization factor, message categorization, interference, and dialogue patterns.

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CONTENTS

US ARMY HUMAN ENGINEERING LABORATORY COMMUNICATIONS SURVEY-A PILOT STUDY (HELCOMS-PS)

EXECUTIVE SUMMARY

During March and April 1983, 5 hours of voice radio traffic were collected at National Training (NTC) exercises in Fort Irwin, CA. The 5 hours consisted of five non-consecutive one-hour samples covering peak period traffic on the command nets of two tank companies, two mechanized infantry companies, and one mechanized infantry battalion task force. Each of the hours was independently and subjectively chosen on the basis of intelligibility and net activity. This limited traffic sample underwent a detailed exploratory analysis. The results of that exploratory analysis, titled the Human Engineering Laboratory Communications-Pilot Study (HELCOMS-PS), are described in this report.

This pilot study was conducted to identify human performance issues of tactical radio communications. As this pilot study involves a limited sample size, it would not be advisable to draw any firm conclusions from the findings listed below.

The units surveyed used their nets about 29 percent of the time, yet the expected wait time for a given station on net was 28 seconds. This condition (i.e., the low usage factor coupled with the long wait time) is caused when many users try simultaneously to access the net.

Station usage analysis revealed that within one company the cumulative platoon leaders net usage time tended to be inversely proportional to the company commander's net usage time.

The high frequency of interference impacted heavily on transmission success. Over 30 percent of all transmissions were lost due to interference.

Garble and static were the greatest interference factors. An in-depth study of interference would be required to determine the specific nature (i.e., equipment, environment or manmade) and the degree of impact on effectiveness.

Across all samples, 65 percent of the transmission attempts resulted in successful transmissions. An average of 21 percent of net usage involved successful transmissions. The mean transmission length was 3.2 seconds. The total successful transmission times and mean transmission lengths were consistent across the five nets surveyed.

For the individual 1-hour samples, the percentage of successful transmissions tended to increase as the number of attempts decreased (or vice versa, the harder the users tried, the less successful they were).

One hundred twenty-four messages were transmitted during the total 5 hours. The range among one-hour samples was rather large (i.e., 19-30).

Messages were found to break down into nine subject categories with command and control as the main subject in the 5 hours (i.e., 34 percent).

The elapsed time for messages in each 1-hour sample tended to decrease when the actual transmission time increased. It could be concluded that the longer transmission time was attributable to "doing one's thinking" while transmitting, whereas, the longer elapsed time (longer pauses between transmissions) could be attributable to "doing one's thinking" between transmissions.

There was an obvious disregard for proper military terminology and proper procedure words.

Fifty-two percent of all successful transmit time was involved with call signs and related procedures. The 52 percent included a lot of "home-made" short cuts on the part of the users. If the users had followed the correct procedure, it was estimated that the net usage factor would have increased from 29 to 43 percent with a corresponding expected wait time increase from 28 to 49 seconds.

US ARMY HUMAN ENGINEERING LABORATORY COMMUNICATIONS

SURVEY-A PILOT STUDY (HELCOMS-PS)

INTRODUCTION

A brief literature review and discussions with the cognizant offices of TRADOC Systems Manager (TSM) and Project Managers Office, Single Channel Ground and Airborne Radio System (PMO-SINGARS) led to the determination that tactical radio traffic is currently receiving no more than a cursory analysis. It was further determined that an in-depth analysis of such traffic might provide some excellent human performance data; therefore, this pilot study was initiated to evaluate the feasibility of a detailed analysis leading to follow-on concentrated studies of those human factors aspects of tactical radio communications which appear to degrade the effectiveness and efficiency of field communications.

OBJECTIVE

The objective of HELCOMS-PS was to conduct an exploratory in-depth analysis of recorded tactical radio communications to see if quantitatively expressed trends and indicators could be identified which would provide insight into human performance in the field communications environment. Possible spin-offs perceived were an increased understanding of user requirements, equipment design improvements, radio procedure (training) improvements, and support/reinforcement of other study efforts.

METHOD

Participants

The participants in this pilot study were military personnel operating on the five radio nets sampled. The nets contained between 8 to 17 stations (see Element 3, Table 1C, Appendix C) with normally one operator per station. The participants were members of an armor battalion and a mechanized infantry battalion organized to form an armor-heavy task force and a mechanized infantry heavy task force, respectively. At the time of the data collection, these units were undergoing near realistic battle conditions during scheduled training exercises at the National Training Center (NTC), Fort Irwin, CA. Specific unit and individual identities have been withheld from this report per NTC request.

Apparatus

The participants used the AN/VRC-12 series of FM radio sets without secure voice equipment for communications. Their traffic was recorded by a 40-channel Veritrac Model 5000 Voice Communications Recording System. Cassette copies of select traffic samples were made from the Veritrac for data reduction tasks.

No unique apparatus was employed for the data reduction tasks. Time data were obtained using a pushbutton, momentary-action switch connected to a Hewlett Packard Model 9830A computer. The computer was programmed to produce a printout of the time between switch activations. Narrative traffic was transcribed manually.

Procedure

Tactical communications from peak traffic periods were selected and recorded on cassett. The selection included five 1-hour samples from a total of 15 hours of recorded radio traffic (Table 1), with peak intensity at the 30-minute point. Samples were subjectively chosen on the basis of intelligibility and net activity during peak traffic periods. A transcript of the narrative and time data was produced for all 5 hours of traffic and then analyzed from several different perspectives (see Results and Discussi). A sample transcript along with associated descriptive material are provided in Appendix B.

One of the main constraints placed upon this effort was the requirement to conduct the HELCOMS-PS without any interference to the NTC training mission. Therefore, it was not possible to collect certain complementary data such as radio operator training and experience statistics, radio maintenance status, terrain profiles, etc. as part of the pilot study.

RESULTS AND DISCUSSION

The basic results are provided in Appendix C. These results were analyzed and then organized into composite findings discussed below. It should be noted that these findings have been derived from a limited sample frame size (5 hours) and are, therefore, not to be interpreted as conclusive. They do, however, point out those aspects worthy of further investigation in follow-on studies.

A glossary is included in Appendix A. Notes of explanation are also provided in the Results and Discussion Section where necessary. Table 2 also contains a description of a message and its elements which the reader should be familiar with before reviewing the findings described below.[1]

[1] For a complete discussion of radio telephone procedures see FM 24-1, Combat Communications and ST7-180, Infantry Communication Data, US Army Infantry School, Ft. Benning, Georgia.

TABLE 1

Sample Size Description

Sample	Net Used	Tactical Environment
Hour One	Tank Company Command Net	Offense
Hour Two	Tank Company Command Net	Offense
Hour Three	Mech. Inf. Co. Command Net	Defense
Hour Four	Bn. Task Force Command Net	Offense
Hour Five	Mech. Inf. Co. Command Net	Offense

TABLE 2

Sample Message

Transmission	Purpose	Message Part	Element
Zulu 84. This is Papa 49. Over	Establish radio contact. Originator	Heading	Addressee
Papa 49. This is Zulu 84. Over	Acknowledged receipt, confirms radio contact.	Heading	Originator Addressee
This is Papa 49. We have made enemy contact on Objective Deer. Over	Transmit information	Text	Subject Matter
This is Zulu 84. Roger. Do you need assistance	Acknowledge receipt of subject matter and request for additional information.	Text	Subject Matter
Papa 49. Negative. Out.	Response to query terminate message.	Text and Ending	Subject Matter Sign-Off

Definition of Terms (Message Elements)

Tactical radio communications involve a simple message form with a minimum of elements: originator (caller), addressee (receiver), subject matter, and ending. A complete message normally consists of several transmissions. A sample message is shown in Table 2; it is treated as a single message containing one subject that is categorized under the title "Situation Report." The sample message could have included numerous text transmissions regarding enemy contact or transmissions related to other categories such as casualties, exact position location, or enemy intelligence. The sample message could have included some unsuccessful transmissions (i.e., exhibited interference) and were, therefore, possibly repeated.

For the purposes of this report, a complete message is defined as "an exchange of transmissions which ends when one or both stations voluntarily stop the exchange of transmissions for reasons pertinent to the subject matter." This would mean a message would be ended by the term "out" (for example) rather than by some technical difficulty.

Figure 1 illustrates the structure of a message with the time elements identified.

Finding: Net Usage

Usage factor was defined as the percent of time that the net was occupied for all transmissions (to include unsuccessful ones) during the sample period. The utilization factor for the five 1-hour periods ranged from 23.3 to 35.7 percent. The average usage factor was 29.2 percent or about 18 minutes per hour. The expected wait time for a caller to access a net was 28 seconds. Calculations for the expected wait time derivation are described in Appendix D.

A subjective analysis of the sample traffic indicated that peak periods existed within the one-hour sample of "peak period traffic." This fact helped to explain the relationship between the seemingly low usage factor results and the relatively high expected wait time. In other words, a lot of periods were found where everyone wanted to communicate at the same time. This phenomenon was also apparent in the considerable amount of interference found (discussed later in this report).

Jamming: The rendering of a radio signal unintelligible or ineffective by the deliberate introduction of electrical signals.

Override: The neutralization of a radio signal by a more powerful radio signal.

Static: Disturbing effects produced in a radio receiver by atmospheric or various natural or manmade electrical influences.

Interference Incidents: The number of times interference occurred during the sample time.

Interference Factor: The percent of the times that transmissions were interfered with during the sample time.

Keyed Microphone: The depression of the push-to-talk (PTT) switch of an active microphone; modulation.

Mechanized Infantry Task Force: A task organized force comprised of mechanized infantry and tank companies. It is battalion sized with the preponderance of companies being mechanized infantry.

Mechanized Infantry Task Team: A task organized team of mechanized infantry and tank platoons. It is company sized with the preponderance of platoons being mechanized infantry.

Message: Any thought or idea expressed briefly in plain, coded, or secret language prepared in a form suitable for transmission by any means of communication. A proper message consists of three parts: heading, text, and ending. The parts are subdivided into components which are further subdivided into elements. (See the example on page 7 of the report text.) A message is comprised of several transmissions and normally ends with the procedure word "Out."

Message Subject Categorization: The grouping of messages by subject matter; i.e., position location, intelligence, command and control, etc.

Message Success Rate: The number of successful messages transmitted during the sample time.

Message Elapsed Time: The time from the beginning of the first transmission to the ending of the last transmission in a message. Includes time between transmissions.

Message Transmit Time: The total time used in completing the transmissions in a message. Does not include time between transmissions.

Mean Message Length: The mean time in seconds required to complete the messages transmitted during the sample time.

Message Time Range: The minimum and maximum message times during the sample time.

GLOSSARY

Initial Address: Procedure words used by the originator of a message to include the call signs of the addressee and the originator ("Sierra 36, this is Sierra 26")

Subsequent Address: Procedure words used by the responding station ("This is Sierra 36" or "Sierra 36").

Armor Task Force: A task organized force comprised of tank and mechanized infantry companies. It is battalion sized with the majority of companies being tanks.

Armor Task Team: A task organized team of tanks and mechanized infantry platoons. It is company sized with the majority of platoons being tanks.

Command and Control Activities: Activities at a unit level that were generated at another level; i.e., a directive from the battalion commander may require radio transmissions at the company and platoon levels.

Ending: Procedure words used to indicate that the transmitting station has completed a statement or terminated a message ("Over," "Out," "Roger, over," "Roger, out," or "Wilco, out"). "Wait" is sometimes used for the purpose it implies.

Expected Wait Time: The amount of time a given station on a radio net is expected to wait to use the net.

Idiomatic Dialogue Patterns: Any dialogue trends in segments of the user population which adversely impact on transmission effectiveness.

Interference: Natural or manmade factors which interrupt or interfere with radio transmissions. The Oxford American Dictionary defines interference in a more limited sense as the fading of received signals because of static or unwanted signals. The dictionary definition was not applied in this report as it fails to account for all factors; e.g., terrain and vehicle movement may also cause interference.

Background Noise: Intrusive sound that interferes with received or recorded electronic signals.

Broken/Cut: Not complete or full; interrupted or discontinued radio signals which render a transmission or message to be incorrect or unintelligible.

Garble: An error in transmission, reception, encryption, or decryption which renders a message or transmission incorrect or undecipherable; alteration or distortion that creates a wrong impression or a change in meaning.

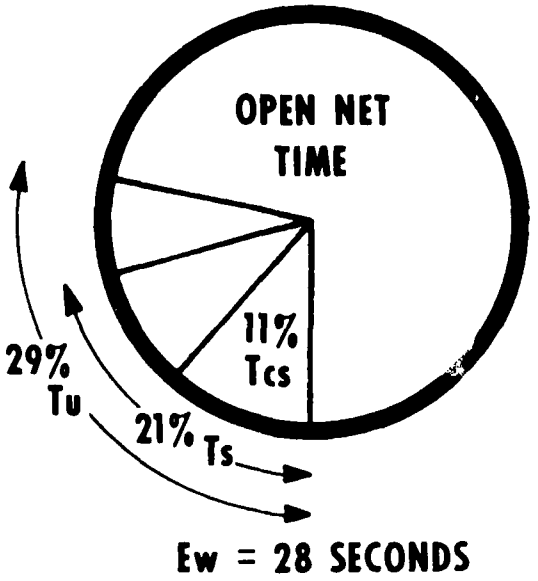
APPENDIX A

GLOSSARY

3. Analyzing concurrent command net samples from several levels of command to evaluate the effectiveness of reports/directives passing up/down command echelons.

4. Analyzing station workload conditions where multiple net involvement is required.

In addition to the specific objectives noted above, the results of this pilot survey have indicated that the effect of net discipline, call sign structure, and radio operator procedures should receive further evaluation. Of these, call signs and associated procedures are considered a priority candidate for further study as they were found to consume over 50 percent of transmit time.



Tu = USAGE TIME **Ts = SUCCESSFUL TRANSMISSION TIME**

Tcs = CALL SIGN TIME **Ew = EXPECTED WAIT TIME**

Figure 8. Call sign time.

This large expenditure of transmission time that is dedicated to call signs suggests that improvements in this area are warranted. To support this suggestion, a time analysis of the call sign procedures was made replacing the "homemade" word short cuts used with correct radio operator procedures. The result was an estimated increase of the net usage factor from 29 to 43 percent with a corresponding expected wait time increase from 20 to 49 seconds.

CONCLUSIONS AND RECOMMENDATIONS

In this pilot survey a detailed exploratory analysis of a limited voice radio traffic sample was conducted. It is concluded that the initial survey results indicate that further similar endeavors would be beneficial. Using the types of traffic performance parameters described in this report recommended points of analysis in future endeavors might include the following:

1. Analyzing jamming effectiveness.

2. Analyzing the impact of Mission Oriented Protective Posture (MOPP) for conditions on communications effectiveness.

A detailed review of the transcripts was conducted to determine to what extent, if any, peculiar language patterns or words are in practice; e.g., geographical slang or citizen's band (CB) jargon. Only seven such cases were found in the total 5 hours. This was not considered to be particularly significant, especially since they were isolated cases. The terms used in those cases were examples of nonstandard military terminology which are described above.

Omitted Procedure Words: An examination of the 5 hours of traffic revealed that transmissions did not always include the address and ending procedure words. Table 5 provides a recap of omitted procedure words in successful transmissions. The data provided in the table showed that 76 percent of all successful transmissions in 5 hours of recorded radio traffic included procedural errors (i.e., 879 (169+358+352) of 1,163 equals the 5-hour total for successful transmissions). Thirty percent (352-1,163) of the successful transmissions had no address and no ending.

TABLE 5

Categories of Interference by Percent

	Hour #1	Hour #2	Hour #3	Hour #4	Hour #5
Garble	67	73	80	4	10
Override	6	0	0	2	22
Broken/Cut	9	8	20	20	29
Static	18	6	0	68	5
Jamming	0	13	0	0	3
Background Noise	0	0	0	6	31

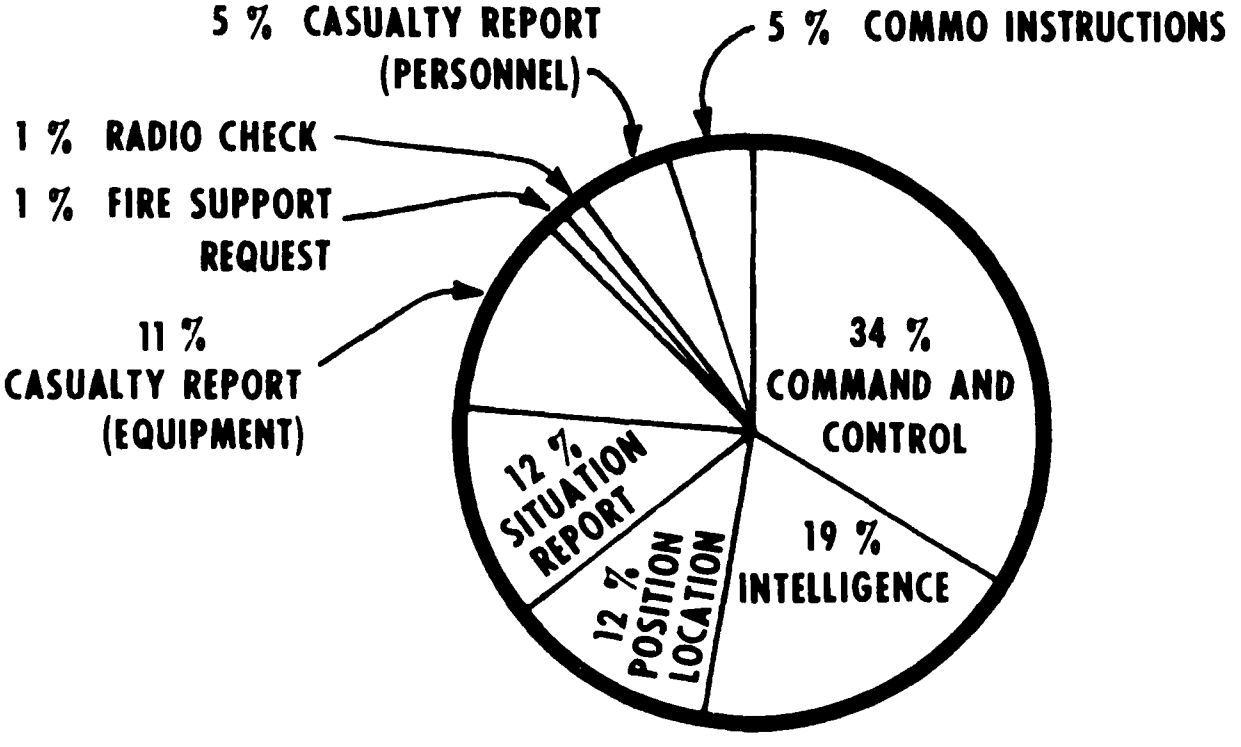
Call Signs: The time required to transmit call signs took up a significant portion of usage time. As illustrated in Figure 8, call sign time (Tcs) consumed 11 percent of the sample time. Even more significantly, call sign time represented 52 percent of the successful transmission time (Ts). This monopoly of transmission time by call signs is particularly significant considering the fact that the call sign procedures observed were frequently abbreviated, followed nonstandard practices, and were sometimes disregarded altogether. This disregard for call signs appeared to present only minor problems during periods of light activity or low traffic density because of voice familiarity; however, during periods of intense activity or high traffic density some confusion resulted and even warranted queries about who was transmitting.

TABLE 4

Message Subject Matter Categories

Category	Net (Hour) #1		Net (Hour) #2		Net (Hour) #3		Net (Hour) #4		Net (Hour) #5	
	#	%	#	%	#	%	#	%	#	%
Command and Control	18	47	11	26	16	46	5	16	9	36
Intelligence	6	16	11	26	4	11	9	28	3	12
Position Location	4	11	4	9	7	20	3	9	3	12
Situation Report	2	5	4	9	4	11	6	19	5	20
Casualty (Equipment)	7	18	5	12	3	9	3	9	1	4
Casualty (Personnel)	0	0	7	16	0	0	2	6	0	0
Radio Check	1	3	1	2	0	0	0	0	0	0
Fire Support	0	0	0	0	1	3	0	0	0	0
Communications Instructions	0	0	0	0	0	0	4	13	4	16
Totals	38	100	43	100	35	100	32	100	25	100

Note: Total for each net could exceed the message success rate because some messages addressed more than one of the specified categories.



matter categories: Five-hour total.

Finding: Message Subject Matter

Message subject matter results are shown in Table 4. The 5-hour composite is depicted in Figure 7. Over one-third of the subject matter concerned command control activities and when combined with the intelligence category, these activities made up over half of the total. Specific nets were found to devote a greater percentage of their times to varying subjects. For example, Net #3's station location reporting occurred twice as frequently as the other nets. This appeared to be caused by the tight control exercised by the company commander which was in a static (defensive) situation in contrast to the other units which were involved in fluid (offensive) operations. One would normally expect less position location reporting in a static situation.

Finding: Dialogue Patterns

Nonstandard Practice: The 5 hours of traffic were filled with nonstandard terminology, procedures, and call signs. Transmissions also frequently lacked specificity and contained profanity.

Examples of nonstandard terminology, procedures, and call signs are listed below. Each example was a complete transmission.

1. "Your dime."
2. "Goin down the road."
3. "David, do you hear me?"
4. "You were walked on."

Examples of ambiguous or nonspecific comments include (complete verbatim transmissions):

1. "Edge around the corner."
2. "Move forward a little bit more."
3. "Goin down the road."
4. "We lost anything yet?"
5. "Contact, contact!"

Direction and distance instructions frequently included "right" and "left," "up" and "back," and "a little bit" or "more." Confusion and repeated transmissions were generated by such terminology in situations where right meant east to the originator and west to the addressee and where "a little bit" meant 100 meters to the originator and one vehicle length to the addressee.

transmission attempts and the interference factor had little impact on transmission success. However, a better explanation would be that transmission attempts and the interference factor tended to cancel each other; i.e., those sample periods that had the greater interference factor forced a greater number of transmission attempts to achieve the same quantity of success. If the latter interpretation of the figures is correct, then the next phenomenon to be questioned is why did all of the sample hours peak at relatively the same successful transmission quantity level? That phenomenon is possibly the saturation level for a single channel queue of the characteristics involved. A larger sample size would answer the question.

Finding: Keyed Microphone

Keyed microphones (circumstances where a microphone was keyed but no voice transmission followed) occurred 115 times in the 5-hour total. These appeared to be mostly an abbreviated signaling procedure application or out-of-range transmissions. Keyed microphones were not counted as transmissions.

Finding: Message Rates

One hundred twenty-four messages were successfully transmitted during the 5-hour total with a range of 19-30 per sample hour. The mean message transmit time was 19 seconds with a range of 3-75 seconds. The mean message elapsed time was 34 seconds with a range of 3-226 seconds. As shown in figure 1, elapsed time includes both transmission time and time between transmissions.

The elapsed time for messages in each one-hour sample tended to decrease with an increase in actual transmission time. It could be concluded that the longer transmission time was attributable to "doing one's thinking" while transmitting, whereas, the longer elapsed time (longer pauses between transmissions) could be attributable to "doing one's thinking" between transmissions. The latter appeared to be the more effective practice because it provided better security and reduced power consumption through shorter transmission times.

The message success rates for hours #3 and #5 were probably higher than evidenced on the recordings. The recordings included one-way conversations. That is, in a two-way conversation, one of the station's transmissions was either not recorded because of the distance or terrain, or the transmissions were blocked out by interference. The other station's transmissions were recorded and it was clearly obvious, by the nature of the recorded transmissions, that a complete conversation (message) had taken place. Such one-way conversations were not counted as successful messages in the analysis.

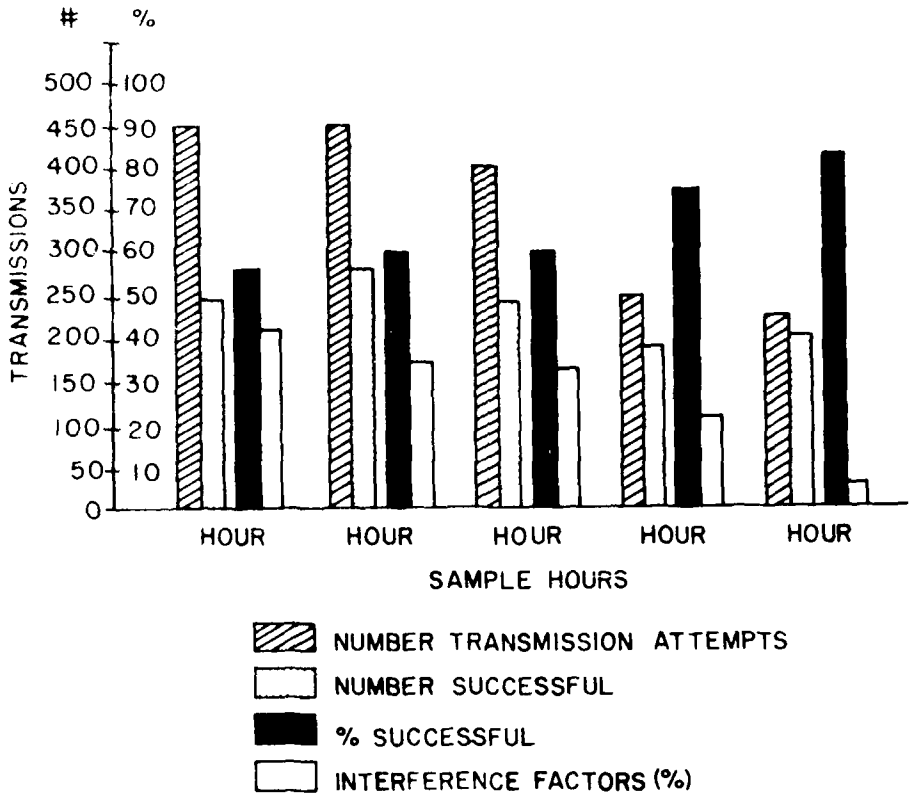


Figure 5. Number and percentage of transmissions and attempts across all sample hours, including interference factors.

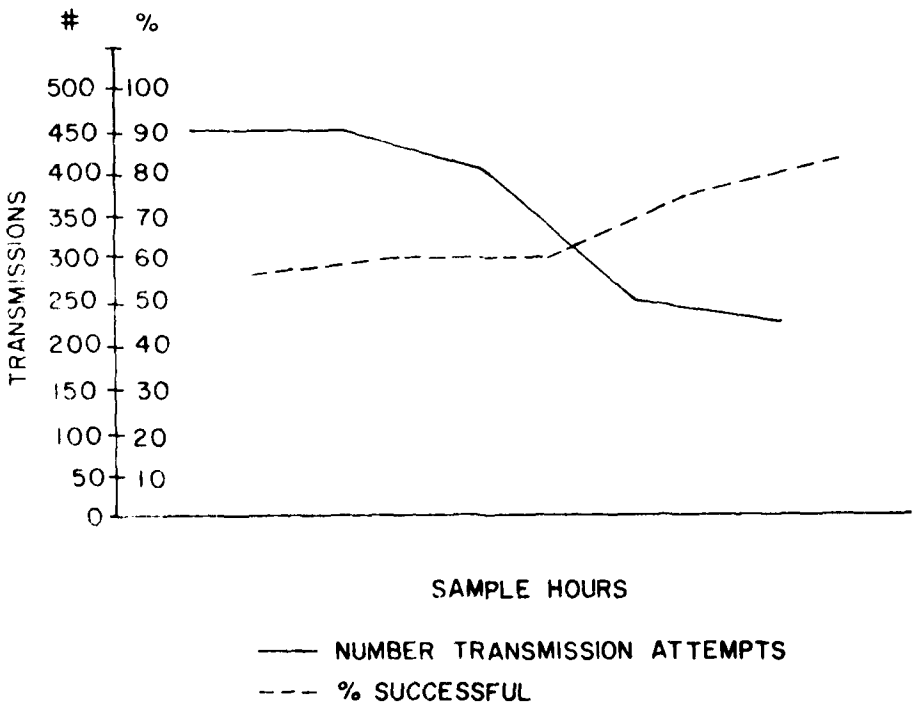


Figure 6. Number and percentage of successful and attempted transmissions across all samples.

TABLE 3

Successful Transmissions and Time Factors

	Hour #1	Hour #2	Hour #3	Hour #4	Hour #5	Average
Number of Transmissions	276	196	200	245	246	233
Mean Transmit Time (Sec)	2.6	3.8	3.8	3.2	3.2	3.3
Range Transmit Time (Sec)	1-16	1-26	1-21	1-14	1-112	

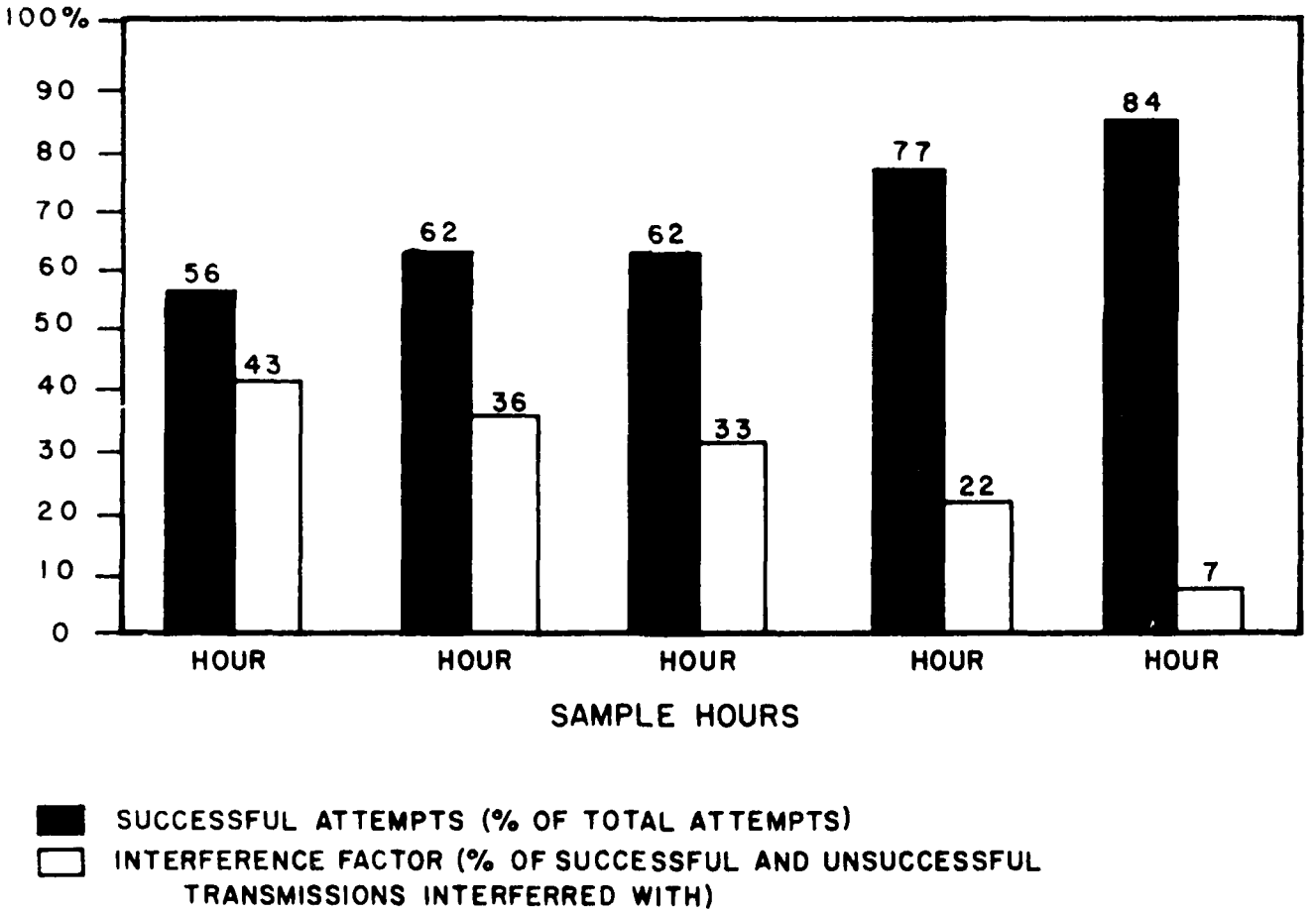


Figure 4. Successful attempts versus interference factor.

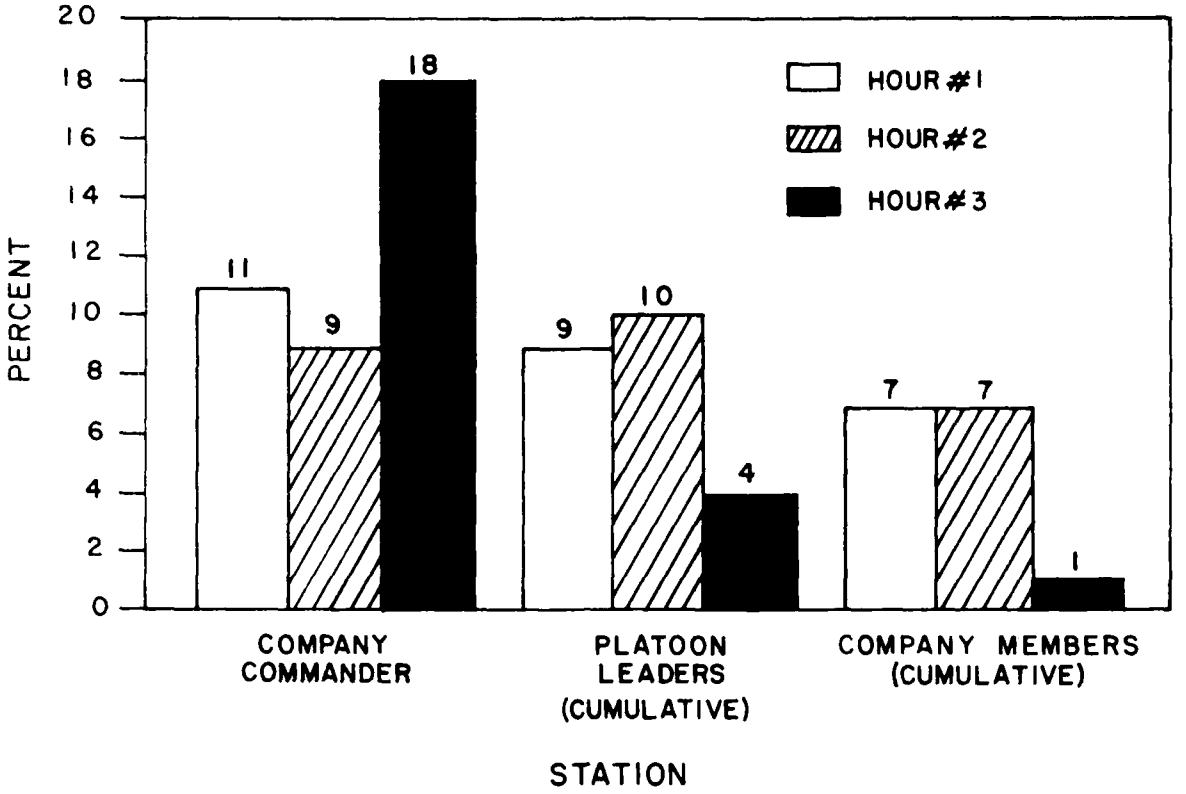


Figure 2. Station usage.

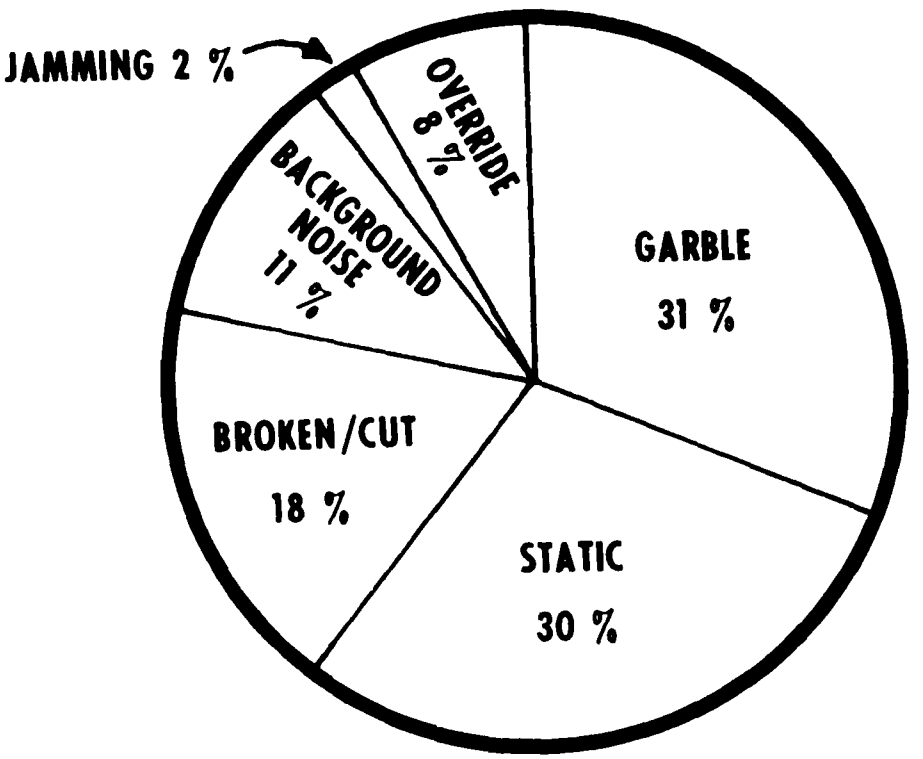


Figure 3. Interference: Five-hour total.

Finding: Station Usage

Station usage is the amount of time, expressed in percent, that a particular stati . transmitted on the net during a sample hour. Station usage data were computed only for the first three sample hours due to the cost of data analysis. The high for station usage was 18 percent. The average station usage was 3 percent. Some stations were identified that were known to exist in the net but did not transmit at all during the sample period.

Figure 2 shows that in two of the sample hours the company commander and platoon leaders used the net approximately the same amount of time. In the third sample hour, however, the company commander used the net much more than anyone else. Reviewing the narrative traffic, it was found that this particular company commander gave a lot of direction and exercised strict control of the net, but received very little feedback from subordinates. If permitted, in future similar efforts it would be interesting to compare such statistics to the unit's performance evaluation.

Finding: Interference

The high frequency of interference impacted heavily on transmission success. Five hundred twenty interference incidents occurred during the 5 hour total. The interference factor (number of interference events per transmission attempts) ranged from 7 to 43 percent for individual sample hours with a 5-hour average of 31 percent. Interference included garbled words, broken transmissions, overrides, static, background noise, and apparent jamming (see Appendix A, Glossary, for definitions). Figure 3 shows the categories of interference in percent for the 5 hours of traffic. Since the types of interference could be attributable to any of several factors (i.e., equipment, environment, radio/telephone procedures), no specific conclusions could be drawn. Without a more detailed study of interference, one could only speculate about the specific causes of the interference. For example, garble and static could have been caused by equipment or the environment. Override and broken (interrupted) transmissions could have been caused by human error or equipment.

The percent of time that all transmission were interferred with is shown in Figure 4. The percent of successful transmissions increased when the interference factor decreased.

Finding: Transmission Rates

For the total 5 hours, there were 1783 attempts to transmit and 1163 successful transmissions. Table 3 shows that the number of successful transmissions and the mean transmission time were rather consistent across the five nets surveyed. This is interesting in light of the previously noted transmission attempt and interference factor sample-hour variances illustrated in Figure 4. To better illustrate this point, the data shown in Table 3 and Figure 4 have been reillustrated in Figures 5 and 6 to better depict their relationships where it would appear that variances in

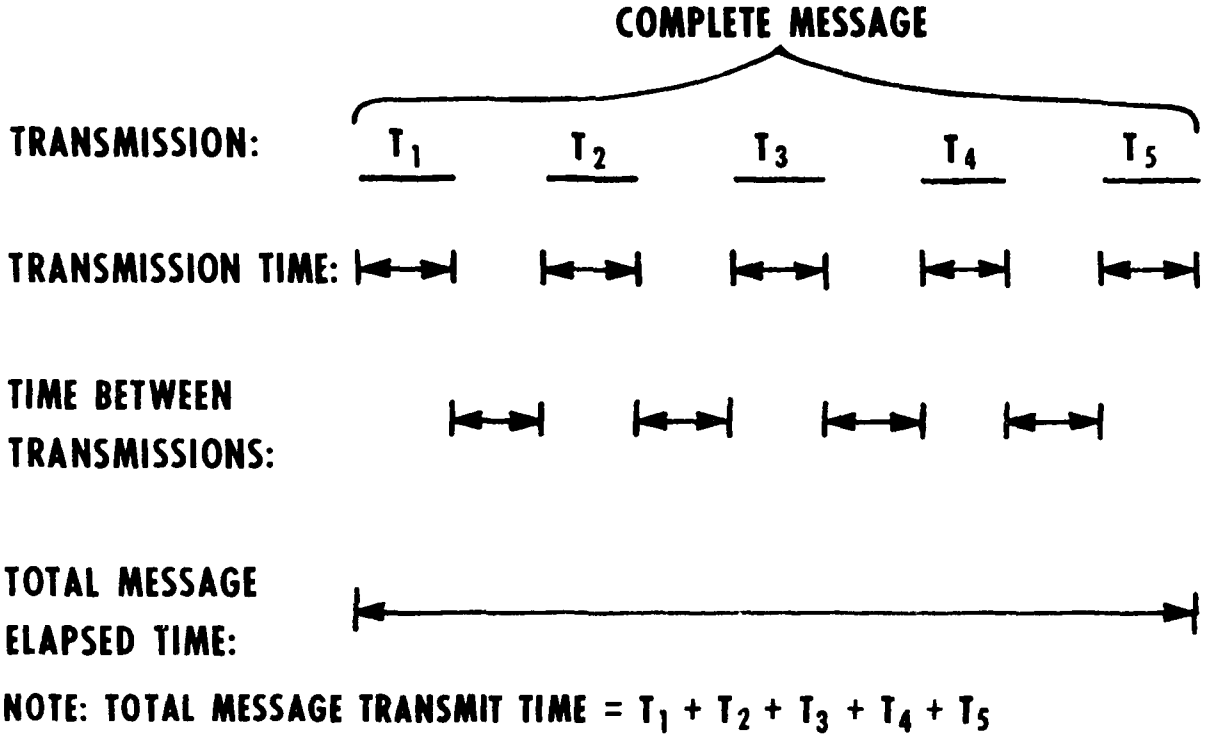


Figure 1. Message structure time factors.

Procedure Word: A word used within a transmission or message in accordance with proper radio-telephone procedures; i.e., "Over," "Out," "Roger," "Wilco," etc.

Sample Time: The amount of time from the first to the last transmission of a recorded segment of tactical radio traffic.

Station Usage: The percentage of time the radio net was used by a given station during the sample period.

Transmission: Coherent modulation on the carrier signal of a radio net through an active microphone; i.e., one with the push-to-talk (PTT) switch depressed.

Successful Transmission: A transmission that is completed without interference (or without sufficient interference to preclude completion of the transmission) prior to releasing the PTT switch. A successful transmission is normally ended with the proper procedure word "Over" or "Out." To be successful, a transmission does not have to be acknowledged.

Unsuccessful Transmission: A transmission that is not completed prior to releasing the PTT switch. Normally, some form of interference precludes the completion of the transmission.

Successful Transmission Time: The amount of time a radio net was used (occupied) for successful transmissions during the sample time.

Mean Transmission Length: The mean of times used in completing the successful transmissions during the sample time.

Transmission Length Range: The minimum and maximum successful transmission times during the sample time.

Usage Time (Net): The total time that the radio net was occupied for all transmissions (successful and unsuccessful) during the sample time.

Usage Factor (Net): The percent of time that the radio net was occupied for all transmissions (successful and unsuccessful) during the sample time.

APPENDIX B

RADIO NET COMPOSITION, DIAGRAM, AND TRANSCRIPT EXCERPT

MECHANIZED INFANTRY TASK TEAM (COMPANY)

RADIO NET COMPOSITION, DIAGRAM, AND TRANSCRIPT EXCERPT

MECHANIZED INFANTRY TASK TEAM (COMPANY)

TAB 1: Radio Net Composition

1. Stations Normally on Net:

Call Sign	Station
Zula 84	Deputy Commander
Zula 42	Executive Officer
Papa 49	1st Platoon Leader
Sierra 49	2nd Platoon Leader
Mike 49	3rd Platoon Leader
Zulu 66	Fire Support Team
Zulu 61	Net Control Station
Zulu 95	Maintenance Officer

2. Other Stations on Net (made at least one transmission).

Call Sign	Assignment
X-ray 34	Battalion Tactical Operations C
Mike 36	1st Platoon Sergeant
Papa 49 Romeo	Asst. Platoon Leader, 1st Platoon
Papa 99	Tank #3, 1st Platoon

3. Stations Not Fully Identified:

Call Sign	Remarks
96	No prefix. An APC or a tank.
89	No prefix. Unidentified. Referred to once. Not in CEOI.
32	No prefix. Tank or APC #2.
24	No prefix. Unidentified. Referred to twice. Not in CEOI.

TAB 2: Sample Radio Net Diagram

Mechanized Infantry Task Team (Company)

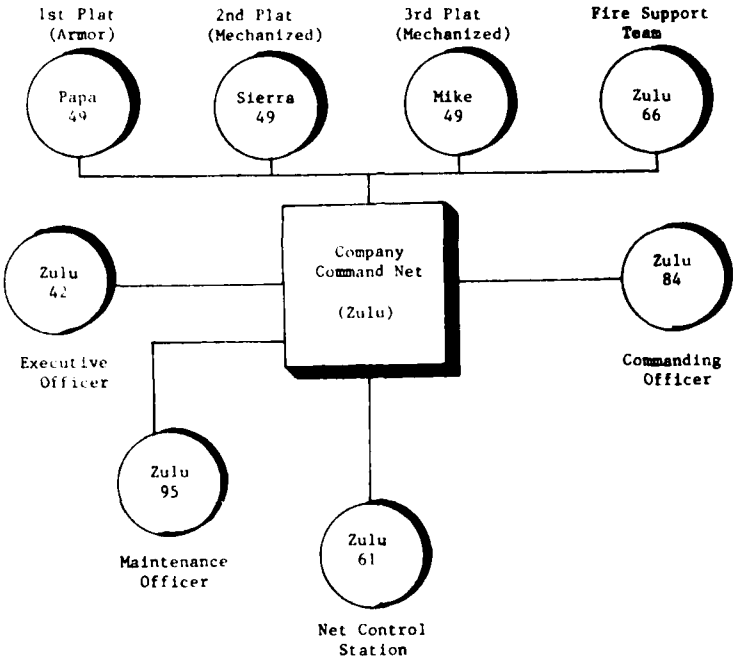


Figure 1B. Radio net diagram.

TAB 3: Radio Net Transcript Excerpt

Sierra 49, 84. If you get the change go on out, run like !@#! and get on Deer if you get the chance, but be careful of our left flank. I got a feeling they're going to come at us from out in the -- (cut) feeling they're going to come from our left flank once we get out there, so watch them.

Zulu 84, Papa 49.

Zulu 84, Papa 49.

Zulu 84, over.

Roger, we have 'em on Deer, and in front of Deer. Dismounted, also 3 track vehicles, break. One BMP, one T72 and one unknown.

Say again their location.

Roger, they're approximately 200 meters east of Deer, over.

Can we get out to Deer without getting our lunch et?

Say last again, over.

Can we get to Deer without getting chewed up?

All I have is three track vehicles, I don't know if they have any dismounted AT capability, over.

Break 96, 84.

You need to get up here where you can get me some shots on Deer real quick. Come on up, there are some good spots up here for you.

95, 42,

Zulu 84, Papa 49.

Zulu 84, over.

Roger, I have dismounted on the ground with AT.

Roger, over.

66, 84 give me something out on Deer. Dismounted enemy.

95, 42.

95.

Roger. This other Victor from that same element is going to need a voltage regulator.

Roger, let me get these other elements up here.

95 this is 42.

95.

Roger, I am advised this Victor you're moving up. They know your sign, they're going to continue to watch for you. If you see someone waving frantically and your're passing them, stop, come back up to them.

This is 95, are you going to continue moving forward? Roger, I'm way behind the action right now. I need to continue forward. These, this Victor is right at the foot of this main hill mass moving along our route.

Do you want the big Victor I have with me to move up to your location? Negative, continue to hold with you. It's maneuverable enough in here, we can move him up if necessary. I'm going to go ahead and move up now.

Keyed mike

84, Sierra 49.

Zulu 84, Sierra 49.

Zulu 84, Sierra 49.

Zulu 84.

Be advised now we got a 1/4-ton with the orange flags, over.

Say again, you cut out.
One quarter ton Victor with orange flags, over.

Roger, that's theirs, that's indirect smoke coming in.

66, 84.

66, 84, over.

66, 84.

Stuff's going in Deer.

Again, you're just, bleeping, that's all.

Break, Papa 49, 84.

49, Zulu 84.

49.

Sitreps.

Roger, enemy track vehicles had turned about headed east, break.

I still have dismounted on the ground.

Keyed mike.

East?

South, southeast.

Keyed mike, two times.

Papa 49, 84

Papa 49, 84.

Papa 49.

I'm getting intel from the other net. It seems that the whole world is just on the other side of Jones. Back in that hole we are talking about.

Roger, we're sitting just north of Jones now and then there's - I don't see any vehicles at all, over.

Roger, Intel tells me there's about 40 or 50 back up in there someplace.

Edge around the corner and take a look up in there.

The element's coming forward to my location?

Again.

The rest of the element is coming forward to my location at this time?

I'll start moving them forward. Are you around the corner?

APPENDIX C

RESULTS

TABLE 1C

Results (Elements 1 through 6)

Element	Hour #1	Hour #2	Hour #3	Hour #4	Hour #5	5-Hour Total	5-Hour Average	Notes
1. Type Unit	Armor Company, Armor Task Force	Armor Company, Mechanized Task Force	Mechanized Infantry Company, Armor Task Force	Mechanized Infantry Company, Mechanized Task Force	Mechanized Task Force (Battalion)			1. Units were cross attached between a mechanized battalion and an armor battalion.
2. Type Radio Net	Company Command	Company Command	Company Command	Company Command	Battalion Command			2. Hours #1, #2, and #3 were from separate exercises. Hours #4 and #5 were from same exercise.
3. Number of Stations on Net	9	9	8	8	17			3. Includes stations not normally on net and stations that made no transmissions.
4. Sample Time (Tape Length in seconds)	3600	3600	3600	3600	3600	18000	3600	4. Time from first to last transmission.
5. Usage Time (seconds)	984	947	840	1284	1196	5251	1050	5. Total time net was utilized (occupied) for all transmission attempts during sample time.
6. Usage Factor (%)	27.3	26.3	23.3	35.7	33.2		29.2	6. Element #5 divided by Element #4.

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TABLE 4C

Results (Elements 7 through 8)

Element	Hour #1	Hour #2	Hour #3	Hour #4	Hour #5	5-Hour Total	5-Hour Average	Notes
7. Expected Wait Time (sec)	(Computed as an average Hours #1, #2, and #3 only)						27.85	See Expected Wait Time, Page 7, for a detailed discussion.
8. Station Usage								Percent of sample time utilized by the net stations. (a) Consisted of nine stations with three not transmitting. (b) Consisted of nine stations with one not transmitting. (c) Consisted of eight stations with one not tra smitting.
Mean (%)	3(a)	3(b)	3(c)					
Range (%)	0-11	0-9	0-18					

TABLE 30

Results (Elements 9 through 14)

	Hour #1	Hour #2	Hour #3	Hour #4	Hour #5	5-Hour Total	5-Hour Average	Notes
9. Number of Interference Incidents	132	51	15	178	144	520	104	Natural or manmade. Did not necessarily defeat the transmission.
10. Interference Factor (*)	33	22	7	43	36		31	Element #9 divided by Element #12 plus #13.
11. Total Number of Attempts to Transmit	450	256	240	437	409	1783	357	Successful transmissions, unsuccessful attempts and keyed microphones.
12. Number of Successful Transmissions	276	196	200	245	246	1163	233	Completed without any interference or without sufficient interference to negate the transfer of intelligence.
13. Number of Unsuccessful Transmission Attempts	128	39	15	173	150	505	101	Transmission broken, overridden, deliberate interference, etc., (see Glossary for definitions).
14. Keyed Microphone With No Transmissions	46	21	25	19	4	115	23	No obvious attempt to transmit after microphone was keyed.

TABLE 4C

Results (Elements 15 through 24)

Element	Hour #1	Hour #2	Hour #3	Hour #4	Hour #5	Sum or Total	Sum or Average	Notes
15. Total Time (sec) for Suc. Trans-mis. (Sec.)	[illegible]	743	704	774	733	[illegible]	757	15. Total time for successful transmissions during sample time.
16. Mean Transmission Length (sec)	3.6	3.8	3.8	3.7	3.2		[illegible]	16. Element #15 divided by Element #12 of Table
17. Minimum and Maximum Trans. Times (seconds)	1-16	1-26	1-21	1-14	1-112			17. Shortest and longest transmissions
18. Message Success Rate/Hour	30	27	26	22	19		25	18. The number of successful messages transmitted during the sample time.
19. Total Message Transmit Time (sec. & min.)	395 sec. (6.6 min.)	520 (8.7)	577 (9.6)	465 (7.8)	361 (6.0)	2318 (38.6)	464 (7.7)	19. Transmit time = total time used for transmissions of a message.
20. Total Message Elapsed Time (sec. & min.)	1163 sec. (19.3 min.)	950 (15.)	865 (14.4)	597 (10.0)	671 (11.2)	4246 (70.8)	849 (14.2)	20. Elapsed time includes time between transmissions within a message
21. Mean Message Length-Transmit Time (sec.	13	19	22	21	19		19	21. Element #19 divided by #18.
22. Mean Message Length-Elapsed Time (sec.	39	35	33	27	35		34	22. Element #20 divided by #18. Elapsed time includes time between transmissions within a message.
23. Minimum and Maximum Message Trans. Time (sec.	4-33	6-43	3-60	6-56	5-75			23. Shortest and longest messages.
24. Minimum and Maximum Message Elapsed Time (sec.)	10-226	9-113	3-77	9-52	5-110			24. Shortest and longest messages.

APPENDIX D

EXPECTED WAIT TIME DERIVATION

EXPECTED WAIT TIME DERIVATION

The model used to generate expected wait time was taken from "Introduction to Queuing Theory."[2] The model assumes that each station independently generates calls at random with rate # when idle. If a caller, when attempting to make a call, is blocked because the net is in use, he waits as long as necessary to use the net. When a station is either using or waiting to use the net, it is considered not idle and generates calls at rate zero during these periods. The distribution of the time durations of messages was assumed to be exponential.

[2] Copper, B. Introduction to queuing theory, (2d. ed.). New York: McMillan Publishing Company, Incorporated, 1972.

The equation used to generate expected wait time {E(W)} is as follows:

$$E(W) = \sum_{j=0}^{n-s-1} \mu^{-1} (j+1) P_{j+1}$$

where:
$$P_j = \begin{cases} \dfrac{n!}{j!(n-j)!} a^j P_o & (j = o,1,---,s-1) \\ \dfrac{n!}{(n-j)!\ s!\ s^{j-s}} a^j P_o & (j = s, s+1,---,n) \end{cases}$$

$$P_o = \left[\sum_{k=0}^{s-1} \frac{n!}{k!(n-k)!} a^k + \sum_{K=s}^{n} \frac{n!}{(n-k)!s!s^{k-s}} a^k \right]^{-1}$$

$$a = \frac{\mu^{-1}}{\gamma^{-1}}$$

$$\gamma^{-1} = \frac{3600n}{N}$$

n = Total number of stations

s = Total number of nets available to the stations

μ^{-1} = Average message length (seconds)

γ^{-1} = Average time between calls generated at a given station (seconds)

N = Total number of messages sent per hour

Calculations were made for two values of N. One value of N was the total number of successful messages. This calculation implies that the net was used only for successful messages. This gives a waiting time that is too low since we know that the net was used for both successful and unsuccessful messages. A more realistic E(W) is obtained if the blocking effects of all messages are factored in. This requires a knowledge of the number of unsuccessful messages and their duration. Unfortunately, this information was not available. However, an approximation was made to introduce the additional blocking effect due to usage of the number of successful messages per hour to the point where it reflects the usage of the net by both successful and unsuccessful messages. The total net time for all transmissions and the total net time for all transmission contained only in successful messages were known. There were, respectively, 924 and 497 seconds. The difference between these two numbers, 427 seconds, represents the total transmission time for transmissions associated with unsuccessful messages. The average transmission time per successful message was 17.75 seconds. The number 427 divided by 17.75 yields 24, the number equivalent sucessful messages represented by the 427 seconds of unsuccessful net usage. Adding the 24 equivalent successful messages to the 28 observed successful messages gives 52. This is the second value of N for which an E(W) was calculated and is believed to produce a more valid E(W) since it accounts for total net usage.

E(W) was calculated for the average of hours #1, #2, and #3. For ease of reference, the necessary data elements are provided in Table 1D. The calculation results used to obtain expected at wait time are shown in Table 2D.

TABLE 1D

Expected Wait Time Data Elements

	Hour #1	Hour #2	Hour #3	Average
Number of Stations	9	9	8	9
Message Success Rate/Hour	30	27	26	28
Total Successful Message Transmit Time (seconds)	395	520	577	497
Total Successful Message Elapsed Time (seconds)	1163	950	865	993
Mean Successful Message Elapsed Time (seconds)	38.8	35.2	33.3	35.8
Total Usage Time	984	947	840	924

TABLE 2D

Expected Wait Time Calculation

	Successful Messages	Equivalent Successful Messages (Incorporates the Blocking Effect Attributed to Unsuccessful Message Time)
Number of Messages/Hour (N)	28	52
Number of Nets (s)	1	1
Mean Message Length (μ^{-1})	35.8 sec.	35.8 sec.
Number of Stations (n)	9	9
$\gamma^{-1} = \frac{(3600)9}{28} =$	1157.14 sec.	$\frac{(3600)9}{52}$ = 623 sec.
$a = \frac{\mu}{\gamma - 1} =$	.03094	.05756
P	.73229	.52756
E(W) Seconds	12.44	27.85

Total Usage Time; 924 Seconds

Average Transmission Time Per Successful Message: $\frac{497}{28}$ = 17.75 Seconds

Total Equivalent Successful Messages: $\frac{924}{17.75}$ = 52.06 (rounded to 52)

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