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HUMAN FACTORS AND SAFETY EVALUATION OF THE
SPECIAL COMMUNICATIONS SYSTEM AN/GSC-40
COMBINED GROUND COMMAND POST TERMINAL

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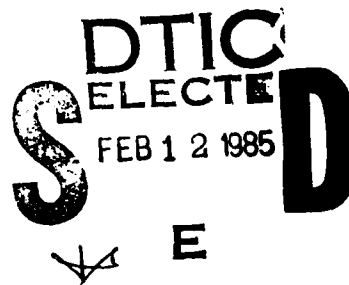
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20. ABSTRACT (Continue on reverse side if necessary and identify by block number) This report documents a human factors and safety evaluation of the AN/GSC-40 combined ground command post terminal by the Army Research Institute. The evaluation was conducted at USEUCOM headquarters and USAFE headquarters in Europe in Jan-Mar 83, in conjunction with a TCATA field test of the system. The overall field test was designed to assess the operational effectiveness and military utility of the AN/GSC-40. Data collected included instrumented physical measurements, observations by human factors engineers, interviews and questionnaire responses. The report concludes that the human factors		

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and safety considerations of the system supported its operation and maintenance in an operational environment, but that a number of problems precluded optimal use of the system. These problems and recommendations for corrective action are documented in the report.

FORWARD

Recent technological advances in electronics have been capitalized on by the Army and other defense agencies to provide reliable high level communications systems. Such systems are necessarily complex, but must frequently be operated and maintained by soldiers of average capabilities. Consequently, it is imperative that such systems be evaluated in order to insure that the user-equipment interface has been safely and adequately designed from this perspective.

In this regard, U.S. Army Research Institute is frequently tasked by various Army organizations, such as the TRADOC Combined Arms Test Activity (TCATA), to conduct human factors and safety evaluations of selected systems in an operational field test environment. The present human factors and safety evaluation of the Special Communications System is a result of such tasking.

The findings of this report were approved by TCATA and integrated into TCATA Test Report OTN 704B entitled: (U) Field Operations Evaluation of the Special Communications System AN/GSC-40 Combined Ground Command Post Terminal in Use With AN/MS-64 Force Terminals (SECRET), September 1983.

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HUMAN FACTORS AND SAFETY EVALUATION
OF THE SPECIAL COMMUNICATIONS SYSTEM
AN/GSC-40 COMBINED GROUND COMMAND POST TERMINAL

EXECUTIVE SUMMARY

Requirement:

The AN/GSC-40 combined ground command post terminal is a satellite communications terminal employed as part of the special communications system used for command and control in Europe and the Pacific. It was designed to act as the command post for the Flaming Arrow Net (FAN) and to be interoperable with AN/MS-64 force terminals located in various units, the airborne command post, the Strategic Air Command, and those communications terminals used by the National Command Authority. The TRADOC Combined Arms Test Activity (TCATA) conducted a field test of the system in January through March of 1983 in order to assess its operational effectiveness and military utility. The test was conducted using AN/GSC-40 terminals at the United States European Command (USEUCOM) headquarters and the United States Air Force in Europe (USAFE) headquarters. The ARI Field Unit - Fort Hood was tasked to satisfy the human factors and safety requirements of that test. The following report is in response to that tasking.

Procedure:

Questionnaires and interviews were administered to operators and maintainers of the system in order to obtain information about the system from a human factors and safety perspective. Areas covered included the immediate environment in which the system was operated, individual equipment characteristics, overall equipment configuration, job procedures, and computer software. In addition, a human factors and safety evaluator recorded relevant observations of operations as well as measurements of light levels, sound levels, and physical dimensions of pieces of equipment in those cases where adverse comments had been made by operators and maintainers. The questionnaire results were tabulated, the interviews and evaluator observations were summarized, and the light, sound and physical measurements were compared to appropriate military standards. This information was used to identify user-machine interface problems and safety problems, and to identify ways of solving the problems by equipment redesign, training, or changes in operating procedures.

Findings:

Generally, it was found that the human factors and safety characteristics of the system supported its operation and maintenance in an operational environment. However, a number of problems were found which precluded optimal use of the system. For example, some illumination levels did not meet military standards and numerous problems were documented regarding physical location of equipment, equipment design, software useability, Communications-Electronics Operating Instructions, unit standing operating procedures, operator logs, and safety.

Utilization:

The results of this ARI research will be used by the Army and Air Force as critical input to the decision as to whether or not to field the system in Europe and the Pacific, and as the basis for changes in equipment design, training, operator and maintenance manuals, and safety constraints.

The findings of this report were approved by TCATA and integrated into TCATA Test Report OTN 704B entitled: (U) Field Operations Evaluation of the Special Communications System AN/GSC-40 Combined Ground Command Post Terminal in Use With AN/MS-64 Force Terminals (SECRET), September 1983.

HUMAN FACTORS AND SAFETY EVALUATION OF THE SPECIAL COMMUNICATIONS SYSTEM AN/GSC-40 COMBINED GROUND COMMAND POST TERMINAL

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INTRODUCTION

Background.

In 1976, the Army and Air Force were pursuing separate programs to install satellite communications ground command post terminals at the same locations in Europe and the Pacific. A JCS message of December 1976 tasked the U.S. Army Satellite Communications Agency (USASATCOMA) to examine the feasibility of combining the Army and Air Force General Command Posts. As a result of subsequent meetings, a joint Army-Air Force working group recommended the Army manage acquisition of a Combined General Command Post Terminal (CGCPT). At a formal in-process review in April 1978, approval was granted to an acquisition strategy for the AN/GSC-40 CGCPT. The AN/MS-64 Force Terminals (FT) and the AN/GSC-40 CGCPT were procured as nondevelopmental efforts. Because of delays in the production of the AN/GSC-40's, and the urgent requirement to deploy the AN/MS-64 FT's, a decision was made to procure an Interim Command Post (ICP). A contract was awarded 1 Oct 80, for an AN/MS-64 modified to serve as ICP, pending availability of the AN/GSC-40's.

A test of the ICP controlling a net of 8 AN/MS-64's was conducted in 1981, in Europe, by the U.S. Army Communications Engineering Equipment Installation Agency (USACEEIA). The test of the AN/GSC-40's controlling a net of AN/MS-64's was conducted 15 January - 15 March 1983 (Europe). The purpose of the latter test, which is the subject of this report, was to assess the operational effectiveness and military utility of the Special Communications System. In this phase, the AN/GSC-40 replaced the AN/MS-64 ICP as the controller of the net of AN/MS-64's. Emphasis was placed on gathering information about the AN/GSC-40 since the AN/GSC-64's had already been tested. The proponent was the USA Signal Center and the user was USACINCEUR (Air Force and Army). TCATA was requested to assess the interoperability, compatibility, functional performance and capability of the AN/GSC-40; to assess the adequacy of the logistics support package; and to assess operational reliability, availability and maintainability (RAM). ARI, Fort Hood was requested to evaluate the human factors aspects and safety factors associated with the system, including performance of operators and maintainers wearing MOPP Level 4 clothing, and to make recommendations for system improvement that would permit the operators and maintainers to perform all critical tasks of the communications-electronics operating instructions (CEOI). ARI was also requested to provide information relating to training factors and suitability of training manuals.

The results of this ARI research will be used by the Army and Air Force as critical input to the decision regarding whether this joint Army-Air Force system will be fielded in Europe and the Pacific, and as the basis for equipment design changes the development and modification of training operator and maintenance manuals and the implementation of safety constraints. This research was part of a project directed by the Joint Chiefs of Staff and will have a significant impact on the organization, functions and effectiveness of the Army, Air Force, and Navy General Command Posts in Europe and the Pacific. The research was incorporated into TCATA Test Report OTN 704B entitled: (U) Field Operations Evaluation of the Special Communications Systems AN/GSC-40 Combined Ground Command Post Terminal in Use with AN/MS-64 Force Terminals (SECRET), September 1983.

System Description.

The AN/GSC-40 combined ground command post terminal is a satellite communications terminal employed for command and control in Europe and the Pacific. Two terminals were used for the test: one at United States European Command (USEUCOM) headquarters and one at United States Air Force in Europe (USAFE) headquarters. The AN/GSC-40 was designed to act as the command post for the Flaming Arrow Net (FAN) and to be interoperable with the AN/MS-64 force terminal, the airborne command post and those communications terminals now in use by the National Command Authority (NCA) and the Strategic Air Command (SAC). The AN/GSC-40 is shown in figure 1.

The AN/GSC-40 equipment was physically located in two separate rooms at the command centers. Figure 2 depicts the system components found in the operations area. This system was manned by one operator 24 hours a day, seven days a week. Figure 3 depicts additional radio frequency (RF) equipment racks which were located in a separate room and connected to the equipment in the operations center by signal cables. The system maintainers watched over these latter five racks of equipment.

Issue.

Do human factors and safety aspects of the AN/GSC-40 support operation and maintenance in an operational environment?

Criteria.

a. Human factors and safety aspects of the AN/GSC-40 as identified in the TM's must not prevent the operators and maintainers from performing all critical tasks in accordance with the user CEOI.

b. Operators and maintainers wearing MOPP level II clothing (minus hood and body armor) must be able to perform all critical tasks under the conditions and to the standards identified in the training test support package.

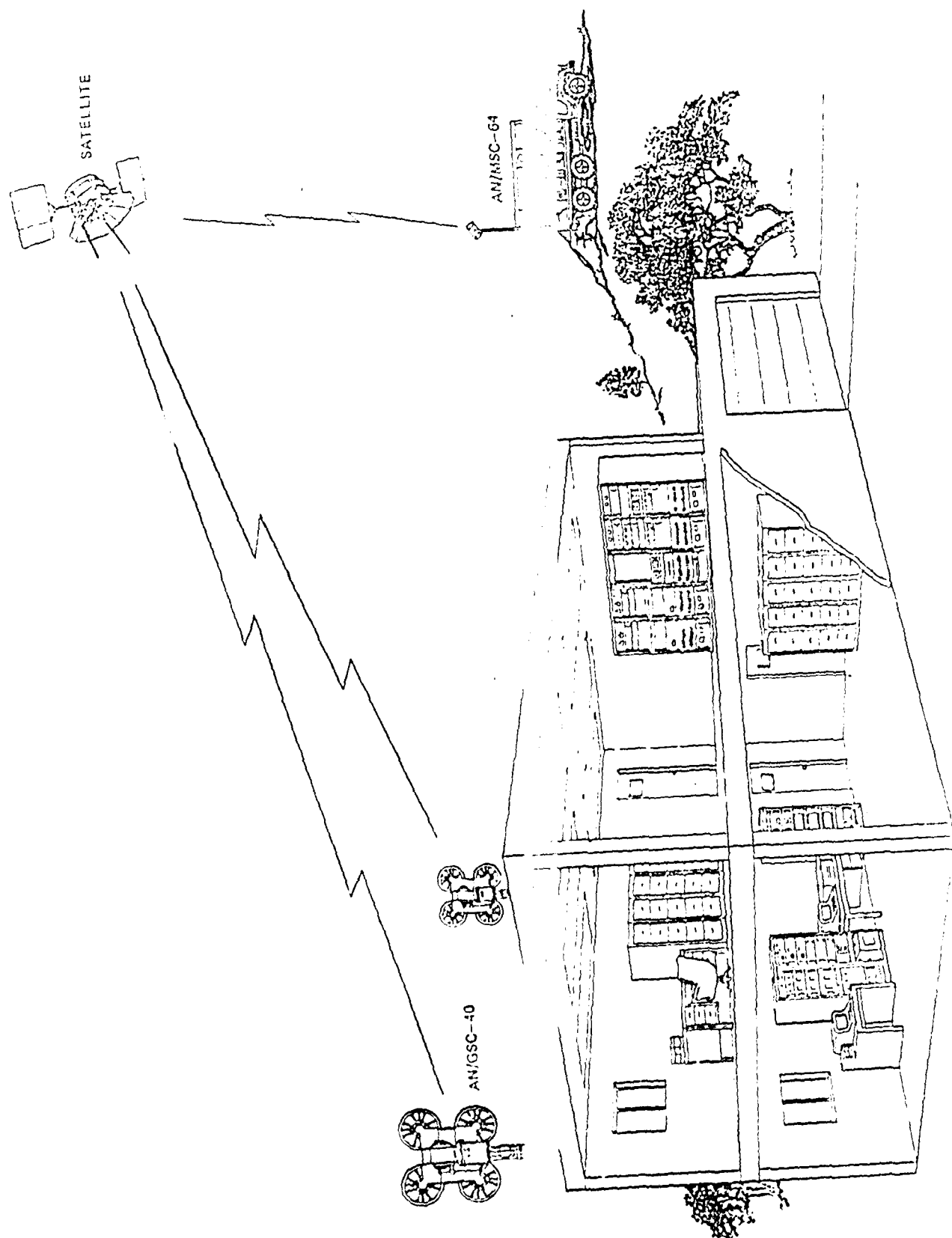


Figure 1. Typical AN/GSC-40 system configuration.

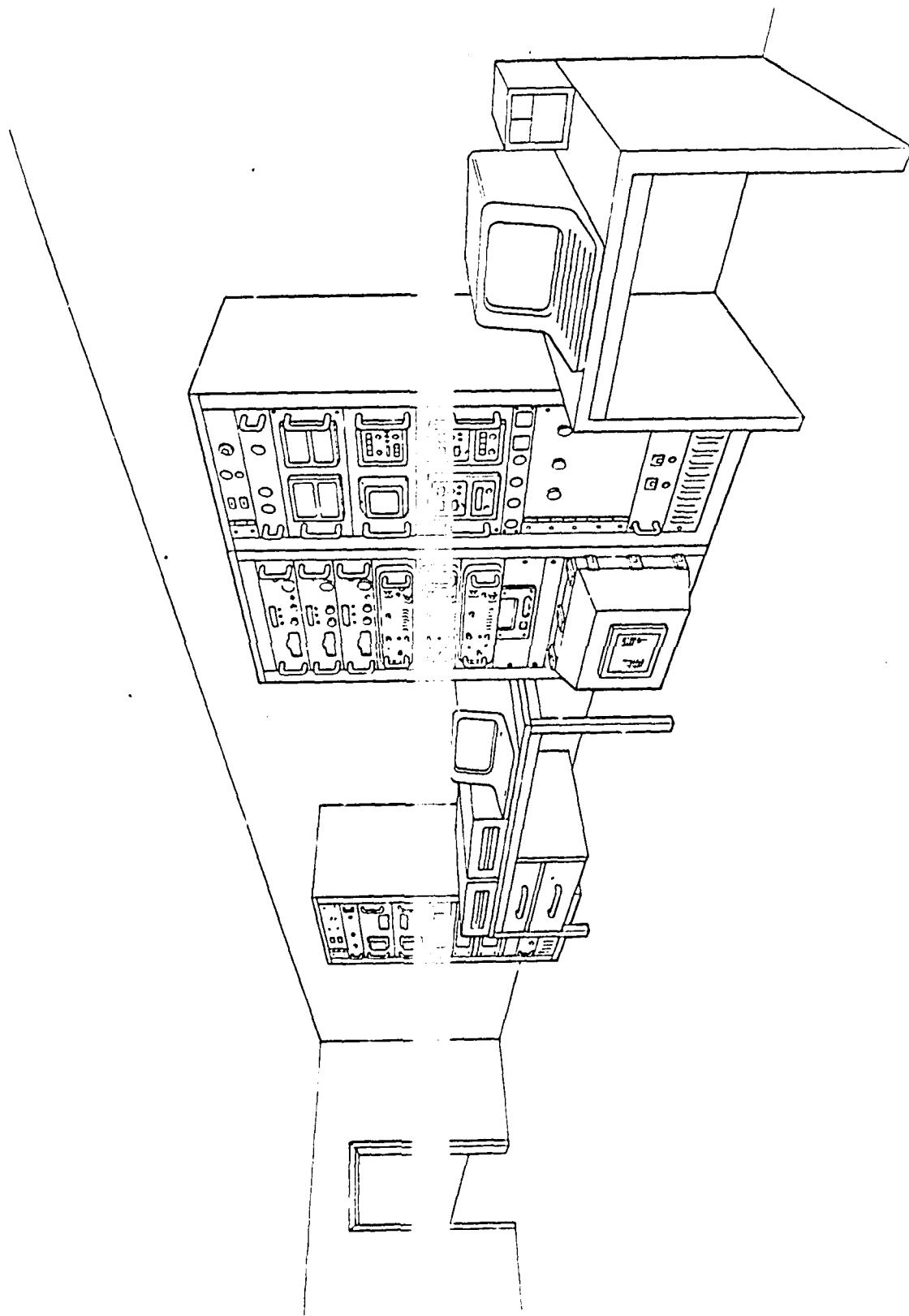


Figure 2. Typical AN/GSC-40 operation and command center.

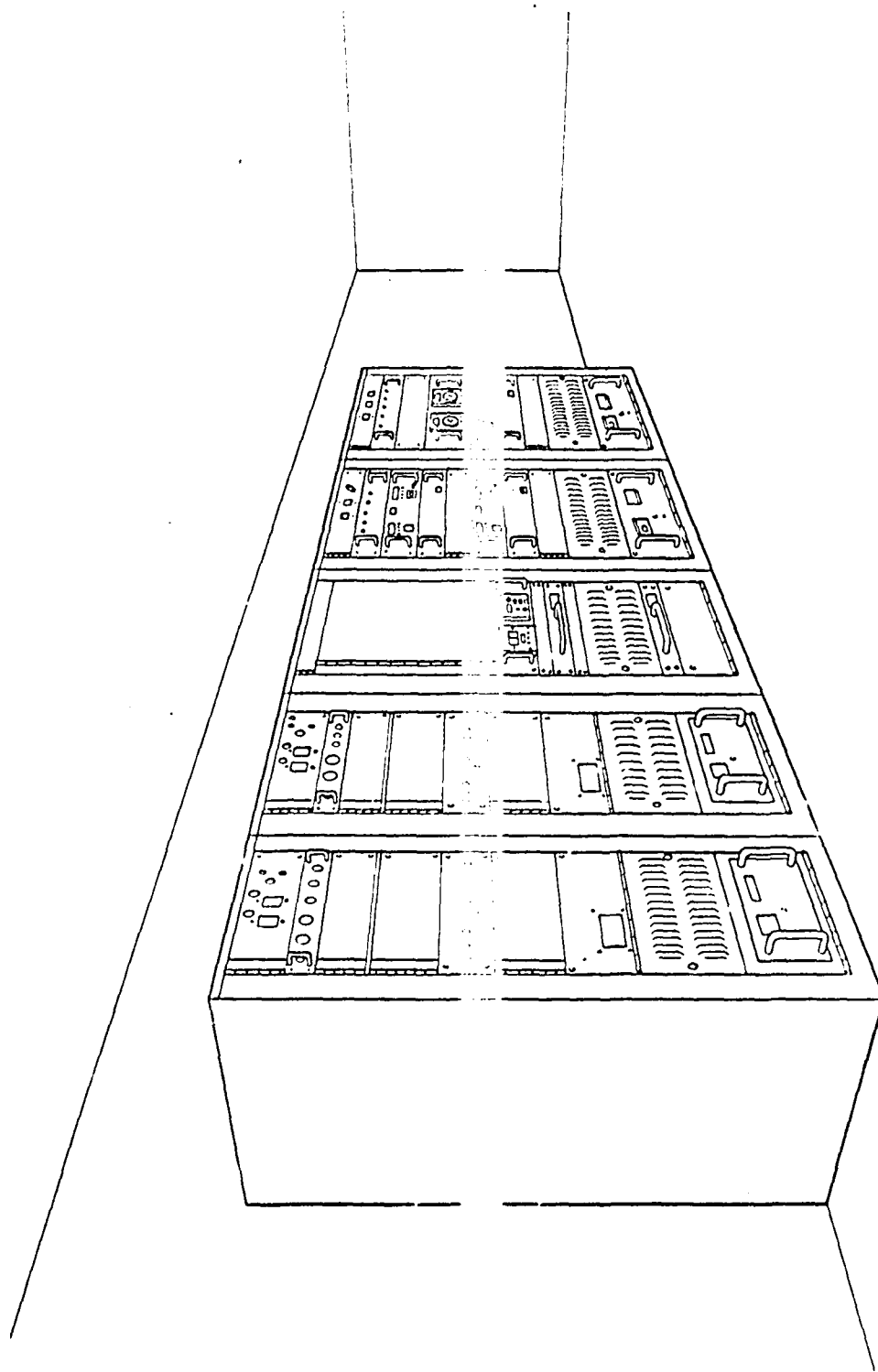


Figure 3. Typical AN/GSC-40 RF equipment room.

METHODOLOGY

Subjects.

At EUCOM there were a total of five Army operators and two maintainers assigned to the system. At USAFE, there were nine Air Force operators and four maintainers. The Army operators were dedicated operators while the Air Force operators operated the AN/GSC-40 as an additional duty to their primary duty at the command center. Demographic data for operators and maintainers are presented in Tables 1 and 2.

Procedure.

a. The 14 operators and 6 maintainers were administered a human factors questionnaire during phase III after they had at least 2-months experience on the system. They were to make comments and provide ratings on their tasks, equipment, procedures, and work area. Adverse ratings and comments that resulted in a possible impact on performing a critical task are stated as findings. Information was also obtained by the human factors-safety evaluator from informal discussions with the training evaluator, contractor support personnel, and the operators and maintainers. The observations of the human factors-safety evaluator are also reported as findings. All of the questionnaire data are available upon request to Headquarters TCATA, ATTN: BATD, Fort Hood, Texas 76544.

(1) Illumination levels were measured three times at various work areas with a spectra M5521 spotmeter. The recommended levels and minimum standards for illumination are 70 and 50 foot candles, respectively, for office areas and 50 and 30 foot candles, respectively, for reading newsprint and for work areas. The operators and maintainers were asked to rate the adequacy of the light levels in their respective areas. Ratings of very inadequate and inadequate were categorized as adverse ratings. Other possible ratings were borderline, adequate, and very adequate.

(2) Sound level's were measured three times with a hand-held 1565B sound level meter, and comments and ratings on sound were obtained from the operators and maintainers. The maximum standards are 65 decibels (dB(A)), for operational areas and 75 dB(A) for general work areas. The same subjective ratings as for illumination levels were used. Both operation centers ran the AN/GSC-40 system with the printer fans turned off to reduce the noise level. At USAFE, the operators rated the effect of noise not only with respect to operating the AN/GSC-40 but also as to how the noise interfered with their jobs. USEUCOM operators rated the effect of noise only with respect to operating the AN/GSC-40. USAFE maintainers performed administrative duties within 10 feet of the equipment racks while USEUCOM maintainers performed those duties in an office in another building.

TABLE 1. SUMMARY OF OPERATOR DEMOGRAPHIC DATA

Operator	Grade	Age	Years service	PMOS or AFSC	Civ Educ (yrs) or degree
USEUCOM					
A	E-5	26	10.0	05C20(V9)	12
B	E-5	27	8.5	05C20(V9)	11
C	E-4	25	5.0	05C20(V9)	12
D	E-5	25	8.1	05C20(V9)	12
E	E-6	27	7.0	05C30(V9)	13
USAFE					
F	E-5	26	8.5	27470	13
G	E-7	46	27.0	27470	13
H	O-4	40	18.0	14952	BS, MA
J	O-4	41	19.0	14952	BSE
K	E-7	39	20.0	274X0	12
L	E-7	31	12.0	27470	AA
M	O-3	30	6.5	1835	BBA
N	E-6	32	12.0	27470	14
O	E-5	28	9.5	274X0	12

TABLE 2. SUMMARY OF MAINTAINER DEMOGRAPHIC DATA

Maintainer	Grade	Age	Years service	PMOS or AFSC	Civ educ (yrs)
USEUCOM					
A	E-5	25	5.0	31EV9	14.0
B	E-5	32	11.5	31EV9	12.0
USAFE					
C	E-7	37	19.0	30476	14.0
D	E-6	33	14.5	30476	13.0
E	E-5	26	8.5	30456	12.0
F	E-5	33	5.6	304X6	15.5

(3) Four times the temperature and humidity were measured with a hand-held psychrometer B4477. The effective temperature (ET), an index used for assessing heat in buildings, was computed from dry bulb and wet bulb temperature readings and air movement. The standard states that the ET should not be less than 65 nor more than 85. The same subjective ratings were used by the operators and maintainers as for illumination. On two occasions the USEUCOM command center became so warm that the AN/GSC-40 was turned off to reduce the heat and prevent other equipment from failing. On several occasions fans were placed in the exits to increase ventilation.

(4) Operators and maintainers used the same five ratings to rate the adequacy of the physical location of the equipment. Maintainers were also asked to rate the adequacy of the workspace. The two test sites were configured somewhat differently in that operators and maintainers at USEUCOM had to walk to a separate building to get to equipment racks 1 through 5.

(5) The major equipment design and software usage problems that were observed by the operators, maintainers, and human factors evaluator are presented as findings in the Results section. Additional data are in sections I and II of the appendix.

(6) The operators and maintainers rated their critical tasks for ease or difficulty of performing the task and the adequacy of the tools and test equipment they had to use. The five ratings for performance were: very easy, easy, borderline, difficult, and very difficult. The ratings for adequacy of manuals and tools were the same as for illumination. Ratings from the two USEUCOM and the four USAFE maintainers were combined because of the small group size. Major findings are presented in the Results section. The means and ranges for all operator and maintainer tasks are presented in section III of the appendix. A mean rating of less than 3.0 was considered adverse for a task.

(7) During phase III, a special noninterference test of normal user operations was conducted for three 24-hour days at USEUCOM and two 10-hour days at USAFE. Throughout this period, the human factors-safety evaluator observed and recorded any problems that affected the overall performance of the AN/GSC-40 in the respective command centers. The CEOI and the Unit SOP's were also examined during this period to determine if they were clearly written and were accurate. Major findings are presented in the Results section. Detailed data are presented in sections IV and V in the appendix.

(8) Prior to the start of phase I, an initial safety inspection was conducted by the human factors-safety evaluator and a bioenvironmental engineering team. A detailed report on this initial inspection is available upon request to Headquarters TCATA, ATTN: BATD. During the operational phase of the test, the human factors-safety evaluator recorded all observations of any potential safety hazards. Operators and maintainers commented on safety hazards they observed during operational phase III. In addition, the requirement for lift-restriction warnings on equipment was examined. The major results are summarized as findings in the Results section. The lift-restriction data are detailed in section VI of the appendix.

b. Even though the criteria called for MOPP level II minus hood and body armor, the test was conducted in MOPP level IV with hood minus body armor. This provided a more stringent and realistic test of actual performance in an NBC environment. During phase III of the test, all 16 operator critical tasks were performed by a USEUCOM operator while the operator was in MOPP level IV clothing minus body armor. Each of the five USEUCOM operators performed three or four of the operator critical tasks under these conditions. The USAFE operators were not tested in NBC gear, because they work in an environmentally controlled center. The two USEUCOM maintainers and the four USAFE maintainers removed and replaced the antenna in MOPP level IV gear only at the USAFE site because the antennas are not located on the ground at the USEUCOM site. Each USEUCOM maintainer performed one performance and measurement test and one or two removal and replacement procedures at the USEUCOM site while in NBC gear. The specific tasks performed were removing and replacing the orderwire dual COMSEC switching unit, the command post synchronizer, and the narrowband Y RT modem, and troubleshooting the diplexer A3A2. These tasks involved handling of cables and test equipment and reaching into small areas.

RESULTS

a. Illumination levels.

(1) Illumination levels at the two sites are shown in Table 3.

TABLE 3. ILLUMINATION LEVEL

(Foot candles)

Work area	Function	Illumination	
		USEUCOM	USAFE
KDU 1	Office work	15	7
KDU 2	Office work	15	5
Printer 1	Reading newsprint	13	13
Printer 2	Reading newsprint	13	9
Front of racks 1-5	Repair work	a	35
Back of racks 1-5	Repair work	a	2

^aNot measured.

(2) One of the nine USAFE operators rated the illumination level in the emergency action cell adversely.

(3) None of the five USEUCOM operators rated the illumination levels in the command center adversely.

(4) All four USAFE maintainers rated the illumination levels in the frame room adversely.

(5) One of the two USEUCOM maintainers rated the illumination levels in the tech control room adversely.

(6) Two USAFE maintainers commented that there was almost no light behind racks 1 through 5.

(7) It was observed that operators and maintainers did not have problems viewing the back lighted keyboard display unit screen, the keyboard, or the equipment rack external controls and indicators.

(8) It was observed that operators had a difficult time discriminating characters on the printer paper.

(9) It was observed that maintainers at both sites had a difficult time seeing the connectors inside the dark interior of rack 3.

b. Sound levels.

(1) Sound levels are shown in Table 4.

TABLE 4. SOUND LEVELS

Work area	Condition	Functional areas	Sound levels (dB(A))	
			USEUCOM	USAFE
KDU	Printer fans off	Operational area	64 ^a	57 ^b
KDU	Printer fans on	Operational area	76 ^a	64 ^b
Racks 1-5				
chest high	Normal	General workspace	71	76
NCOIC desk	Normal	General workspace	75 ^c	69

NOTE: Developmental tests of the AN/GSC-40 in a quiet room indicated that the sound level was only 65.0 dB(A) when both fans were turned on.

^aAt operator station 1.

^bAt operator station 2.

^cNo administrative area for maintainers at USEUCOM.

(2) Eight of nine USAFE operators rated the sound level in the emergency action cell adversely.

(3) None of five USEUCOM operators rated the sound levels in the command center adversely.

(4) Three of the nine USAFE operators commented that the noise level was excessive and higher than it was before the AN/GSC-40 arrived.

(5) Four of the nine USAFE operators commented that the noise in the emergency action cell interfered with normal conversations, working the phones, and passing regular and emergency action traffic.

(6) One of the nine USAFE operators commented that the printer fans were too noisy.

(7) All four USAFE maintainers and one of two USEUCOM maintainers rated the sound level in their respective equipment rooms adversely.

c. Temperature levels.

(1) Temperature levels are given in Table 5.

(2) Two of nine USAFE operators and one of five USEUCOM operators rated the temperature levels in their respective centers adversely.

(3) Two USAFE maintainers commented that the equipment heated up the emergency action cell and that the heat was excessive.

(4) One USEUCOM operator commented that it was too hot, because there was no air movement.

(5) One of four USAFE maintainers and one of two USEUCOM maintainers rated the temperature levels in their respective equipment rooms adversely.

TABLE 5. TEMPERATURE LEVELS

	Dry bulb (°F)		Wet bulb (°F)		Humidity (percent)		Estimated air movement	ET	
Location	Min	Max	Min	Max	Min	Max	(ft per min)	Min	Max
USEUCOM									
Operations	78	85	54	60	20	28	200	67	72
Maintenance	76	--	53	--	20	--	100	67	--
USAFE									
Operations	77	--	58	--	31	--	200	67	--
Maintenance	73	--	56	--	34	--	200	64	--

(6) One USAFE maintainer commented that it was too cold in the equipment room.

(7) It was observed that a space heater was used by the USAFE maintainers to warm up the area by the admin desk.

d. Equipment location.

(1) The number of adverse ratings by operators and maintainers concerning physical configuration of equipment is presented in Table 6.

(2) The number of adverse ratings by maintainers concerning the adequacy of available workspace is presented in Table 7.

(3) In addition to the adverse ratings, the following comments and observations were obtained.

(a) USEUCOM command center.

1 One operator commented that he could not even slide his chair back, because the operator station was next to the main personnel traffic path.

2 Two operators commented that it was difficult to read printer 1 because it was located on the far side of printer 2. Instead, one printer should be on each side of the keyboard display unit.

3 Two operators and one maintainer commented that the space behind racks 6 through 8 was not sufficient for maintenance work.

(b) USEUCOM equipment room.

1 One maintainer commented that the 24 inches for workspace behind racks 1 through 5 was not enough.

TABLE 6. ADVERSE RATINGS CONCERNING
PHYSICAL CONFIGURATION OF EQUIPMENT

Equipment	Number of adverse ratings	
	USEUCOM ^a	USAFE ^b
Operations center ratings by operators		
Rack 6, COMSEC	1	2
Rack 7, FN	1	1
Rack 8, CN	1	1
KDU's	0	2
Printers	1	2
EAM release keys	0	1
Operations center ratings by maintainers		
Rack 6, COMSEC	1	4
Rack 7, FN	1	3
Rack 8, CN	1	3
KDU's	1	0
Printers	1	0
EAM release keys	1	0
Equipment room ratings by maintainers		
Rack 1, CN	1	0
Rack 2, CN	1	0
Rack 3, ant int	1	0
Rack 4, FN	1	0
Rack 5, FN	1	0

^aFive operators, two maintainers.

^bNine operators, four maintainers.

TABLE 7. ADVERSE RATINGS CONCERNING
THE ADEQUACY OF WORKSPACE

Type of workspace	Number of adverse ratings	
	Two maintainers at USEUCOM	Four maintainers at USAFE
Control room workspace	2	4
Equipment room workspace	1	2
Equipment room storage space for tools	1	0
Equipment room storage space for manuals	1	0

2 One maintainer commented that it was difficult to inspect the system, because it was located in two different buildings.

(c) USAFE emergency action cell.

1 One operator commented that it was difficult to see the forward power meter on rack 8, because of intervening safes between operator stations and equipment racks.

2 One operator commented that the antenna controls and indicators were located at the wrong set of racks and should be remoted to racks 6, 7, and 8.

3 One operator commented that the location of the keyboard display units and printers was inconvenient for operations, because the keyboard display units and printer at station 2 were used most often, but all network reports were hardwired to station 1.

4 Three operators commented that the emergency action cell was too crowded with the AN/GSC-40 equipment in it.

5 Two maintainers commented that it was difficult to extend units to work on in rack 6, because of other equipment directly in front of rack 6.

6 Two maintainers commented that the space behind racks 6, 7, and 8 did not permit adequate maintenance on the wiring connectors, because of the extended filter pack on rack 6.

(d) USAFE frame room. Two maintainers commented that it was difficult to use their test equipment that was mounted on a rolling tray, because of the closeness of another set of equipment in front of racks 1 and 2.

e. Equipment design. Twenty-nine problems in equipment design were found. The major problems are listed below.

(1) It was observed that the cable connecting the power control units on racks 1, 2, 3, and 4 got caught between the rack and the unit and became damaged when the maintainer attempted to push the unit back into the rack.

(2) It was observed that the antenna drive switches were unprotected and exposed so that someone could accidentally change the elevation or azimuth of the antenna. (To prevent this, operators and maintainers were verbally instructed to keep the two antenna circuit breakers on the power control panel for rack 5 in the out position, thereby cutting off the power to the antenna drive units.)

(3) Four of fourteen operators commented that the phonetic letter spell out (PLSO) key was not responsive to keying and caused double spell outs. Two operators commented that PLSO mode left a "T" off the North Atlantic Treaty Organization (NATO) Standardization Agreement (STANAG) spelling of "JULIET(T)".

(4) Two operators commented that it was very difficult to read force net messages on the printers, because the messages were intermingled.

(5) Three operators commented that the printed type on the printers was not legible and caused a special problem in distinguishing numbers in force terminal addresses.

(6) Four of fourteen operators commented that the EAM release switches tend to stick in the release position and that this had caused numerous problems in system halts and EAM's being transmitted.

(7) It was observed that the AN/MS-64 operators could defeat the design of the system in monitoring operator status by getting their terminal to automatically send a status to the AN/GSC-40 by lifting up the STATUS key and the REPEAT key. This procedure will continue to send the status once every 5.4 minutes without the force terminal operator being present.

(8) It was observed that the AN/MS-64's lack a fail-safe procedure to prevent accidental activation of the key which indicates operator duress. (This key is located in the same row as the other status keys.)

f. Software usability. Nineteen software usability problems were found. The major problems are listed below.

(1) It was observed that operators have no satisfactory method for monitoring force terminal status changes. (The operator needs to continually check the network member lists, a time-consuming process, because the only change in force terminal status automatically printed is a change to status 5.)

(2) It was observed that there were no automatic warnings that the system was about to halt, because the storage for prompt/error/alert and/or display queue had filled to capacity.

(3) One operator commented that the system did not provide permanent storage for operator initiated messages. Currently, a message is purged from storage when it is called up for transmission.

(4) Two operators commented that it took too long to change the status of a force terminal on network member list, and during this time the entire force net is shut down.

(5) It was observed that it was difficult to incorporate the AN/GSC-40 into other command center functions, because preformatted messages similar to those used in other operational networks were not available. (The machine has the capability of storing preformatted messages.)

(6) It was observed that operators in the command post mode had a difficult time spotting messages specifically addressed to his or her station, because all system message traffic on all nets is printed.

g. Operator and maintainer critical tasks.

(1) None of the tasks, with respect to ease of performance, received an adverse mean rating from the five USEUCOM operators.

(2) None of the procedures in the operator manual, with respect to adequacy, received an adverse mean rating from the five USEUCOM operators.

(3) None of the tasks, with respect to ease of performance, received an adverse rating from the USAFE operators.

(4) Three of the procedures presented in the operator manual received adverse mean ratings with respect to adequacy from the USAFE operators. These procedures were equipment setup and parameter entry for the command post mode and changing satellites.

(5) One task, troubleshooting procedures for the antenna, received an adverse rating with respect to the adequacy of the tools and test equipment for that task.

(6) One task, troubleshooting system faults, received an adverse rating with respect to the adequacy of the maintainers manual.

(7) One maintainer commented that troubleshooting the antenna interface system was difficult, because some of the units were hard to remove.

(8) One maintainer commented that there was a lot of duplication in the three different tool kits.

h. Operational procedures.

(1) Fifty-seven specific problems in the CEOI were found.

(2) USAFE did not have an SOP and the SOP at USEUCOM was incomplete because it did not address areas of operation such as net discipline, run silent procedures, and satellite changeover and satellite command coordination procedures.

(3) During the observation of normal user operations test period, the following problems were observed.

(a) Twelve problems were observed in the operator logs.

(b) Eight specific areas of noncompliance with CEOI procedures were observed.

(c) Operators at both sites failed to continually monitor the system. While USEUCOM was the command post, 24 percent of 318 force net messages were unnecessary operator chatter; and when USAFE was command post, 21 percent of 311 force net messages were unnecessary chatter. USAFE operators could not decipher the meaning of Army force terminal messages, because the Army operators used an abbreviated communicators language replete with codes, such as ZBK and RFO.

(4) During the entire operational test, the following problems with user operational procedures were observed.

(a) When USEUCOM was the force net command post and USAFE the alternate command post, USAFE did not monitor their terminal. Consequently, USEUCOM seldom used the AN/GSC-40 to communicate with USAFE and seldom transmitted encrypted traffic to USAFE in order to test if they had set their crypto keys correctly. As a result, operators at both sites were never sure their encrypted nets were in fact operational.

(b) Twice USEUCOM and the entire force net were off the air for several hours because USEUCOM did not receive updates on the current code for synchronization of the force net in TDM-2 operations.

1. Safety.

(1) The following safety deficiencies were noted in the initial safety inspection.

(a) There was a need for antenna radiation hazard signs and a restraining fence at the USAFE site.

(b) "High Current" warnings in antenna function boxes were missing.

(c) There were no blade guards on blower assemblies in racks 1 through 6 and in rack 8.

(d) Two-man lift signs for units over 35 pounds were missing.

(e) The main circuit breakers for equipment racks 6 through 8 in the USAFE emergency action cell were difficult to access.

(f) The emergency lighting in the equipment room at USAFE was insufficient.

(g) The main circuit breakers were inaccessible to maintainers in the command center at USEUCOM. (The circuit breakers are in a separate room that require an additional security clearance which the maintainers do not have.)

(2) During the operational phase of the test, the following comments and observations were made.

(a) Three of the five USEUCOM operators commented that they received a static electric shock if they touched the equipment after walking across the room.

(b) One maintainer commented that there was no warning that the system should be put into the loop-back mode before initiating maintenance on the antenna to prevent accidental exposure to radio frequency energy.

(c) One maintainer commented that there should be a warning to wear hard hats during antenna replacement operations, because the antenna was raised and lowered while above the head.

(d) One maintainer and one operator at USAFE commented that the EAM alarm console at station 2 had sharp corners and because of its position on the end of the equipment racks it was a hazard to personnel walking by.

(e) One operator at USEUCOM and one at USAFE commented that the printer gave off noxious fumes during a core dump.

(f) Two maintainers commented that the 400 hertz 115 volt power to the antenna did not have a circuit breaker. (Although the system is fused for overvoltage protection, there is no easy way to interrupt the power for antenna maintenance actions.)

(g) One maintainer commented that the blower chassis are on slides without stops and could be pulled out too far.

(h) Two USEUCOM operators commented that there were no fire extinguishers in the command center. (There is in fact one, but it is hard to find.)

(i) Two maintainers at USAFE commented that there was a possibility that some AN/GSC-40 units contained the toxic chemical polychlorinated biphenyls (PCB), because they had turned in a wideband modem with symptoms such as "leaking oily-like substance from the unit."

(j) One instance was observed where a safety precaution precluded the maintainer from completing a maintenance task.

(k) The following findings were obtained from the examination of equipment lift restrictions.

1 In no cases did the warnings on the equipment contain information concerning the unit weight.

2 In 6 of 13 instances, the TM warning was not in agreement with the requirement.

j. NBC operations.

(1) The operators experienced no difficulties in performing all operator tasks in NBC gear but sweated profusely in their MOPP clothing.

ASSESSMENT

Human factors and safety aspects of the AN/GSC-40 do support operation and maintenance in an operational environment, although a number of hardware, software, environmental, and procedural problems hinder the most effective use of the system.

APPENDIX A

I. Observations and comments concerning equipment design problems are as follows:

a. Three of six maintainers commented that the power-on light for the PP-7120/G power supply on racks 1, 2, 3, and 4 was the wrong color; it was red instead of green. (Red lights should only be used to alert operators that a portion of the system is inoperative. Green lights should be used to indicate power-on status per MIL-STD-1472B para 5.2.2.1.18.)

b. Two of six maintainers commented that the power-on light for the PP-7120/G power supply on racks 1, 2, 3, and 4 was hidden from view by the noise baffle.

c. It was observed that the DC5 test transmission coupler in rack 3 was very difficult to remove, because the maintainer could not get a screwdriver behind it to take out the retaining screws.

d. One maintainer commented that the radio frequency power meter on the narrowband receiver-transmitters (RT's) (RT-1336/G) did not appear to give an accurate measurement of actual power-out. (Any power-out will move the meter indicator from 0 to 100.)

e. It was observed that the cables out of connections J1 and J2 on rack 5 loop down and prevent opening of the maintenance panel on the rear of rack 5.

f. Two United States European Command (USEUCOM) operators commented that the function of the QUERY indicators on rack 8 were not clear to them.

g. Three of six maintainers commented that the power-on light for the PP-7516/G power supply on racks 6 and 8 was the wrong color.

h. One maintainer commented that there was an additional filter on the back of rack 6 which was added after maintenance training and that the maintainers had received no instructions regarding the modification.

i. One maintainer commented that it may be difficult to replace the KG-31, because it was difficult to reach behind the KG-31 inside rack 6 and replace cables without being able to see the cables and connectors.

j. Five of fourteen operators commented that the power-on switch on the PP-7516/G power supply at racks 6 and 8 had been accidentally turned off by shoes brushing against it. The switch does not have a guard.

k. Two of the five operators at USEUCOM commented that the receiver busy lamps on the frequency selector units C-9693(V)2/N on rack 8 were not very durable. They were constantly burning out. At one time three of the four "on" lights were burned out.

l. It was observed that in the time division multiplex-2 (TMD-2) mode messages of more than 40 characters were received on only two of the four unencrypted command net (UCN) channels. The two effective channels were those on which the synchronizer select switch is set.

m. One United States Air Forces in Europe (USAFE) maintainer commented that the antenna junction box was in a bad position because when it was opened for maintenance rain and snow could get in.

n. It was observed that the margin set key was sometimes inadvertently activated by the operator, and the operator was confused when the cursor would not go to all locations in the menu.

o. It was observed that the keyboard lockout override button and the master clear switch were no longer necessary, and if either one was activated at the wrong time it would render that keyboard display unit unrecoverable without a reinitialization.

p. It was observed that if the start of text (STX) key were inadvertently hit in place of the end of text (ETX) key the keyboard display unit would become unrecoverable without a reinitialization. (The STX key is close to the ETX key.)

q. It was observed that the paper never stacks neatly in the printer paper tray. The paper usually ends up hanging over the back of the printer and falling to the floor.

r. All five operators at USEUCOM commented that the low-paper indicator lamp on printer 2 did not work, and even the one that did work was a soft orange color and often was not noticed by the operator.

s. Two USAFE operators commented that the printer paper was too expensive.

t. One USAFE operator commented that the printer fans were not effective in eliminating fumes while core dumps were being taken.

u. It was observed that the operators were often confused because the command post synchronizer uses narrowband 1 and narrowband 2 to identify the narrowband A and narrowband B modem controls.

II. Observations concerning software usability problems.

a. Error warnings (number of P/E/A's and displayed queue) were nondynamic.

b. The UCN RT assignment menu did not match operator knowledge of hardware settings on narrowbands B and A modem controls. Consequently, it took a long time for operators to learn how to use the current UCN RT assignment menu.

c. There was no status display for UCN and force net parameters. (When the current UCN and force net parameter entries are called up, they come up blank rather than with the current parameters.)

d. The force net status reports displayed on the keyboard display unit had three defects:

(1) Caused the operator to devote much time (3 per frame) to keep the display queue empty.

(2) Took up memory space when display queue built up.

(3) Not necessary because they were also automatically printed, and needed only go to keyboard display unit if a message updating force net status was desired.

e. The address screening procedure did not work correctly. (In the force net, use of address screening resulted in only the first line of message text being received. In the UCN and encrypted command net (ECN), address screening did not work, because message headers do not contain terminal addresses.)

f. The operator could not tell from reading a printer message if a wideband message was transmitted from wideband 1 or wideband 2 transmitter.

g. Preformatted messages required by the Communications-Electronics Operating Instructions (CEOI) are not available.

h. Use of numeric status codes in the AN/GSC-40 was inconsistent with letter status codes used in the AN/MS-64's.

i. The use of "N" or "Y" instead of "T" or "G" in the force net message control menu was inconsistent with the AN/MS-64 format.

j. Operators did not have flexibility in assigning status reports and queues to either of the two keyboard display units and/or to either of the two printers.

k. Message precedence was not included in the channel demand report.

l. Operators could not print the network member list to obtain hard copies for record.

m. There was no easy way to transfer to the alternate command post the network member list or changes to the list as dictated in the CEOI.

III. Findings concerning operator and maintainer ratings of their respective critical tasks are in tables A-1 and A-2.

TABLE A-1. OPERATOR RATINGS OF TASKS PERFORMED

Operator task	Ease of performance			Adequacy of manual		
	Mean	Range	No	Mean	Range	No
USEUCOM						
Equipment set up--CP	4.6	5-4	5	3.6	5-2	5
Parameter entry--CP	5.0	--	5	4.2	5-3	5
Initialize MPU	5.0	--	5	4.7	5-4	3
XMIT UCN	4.2	5-3	5	4.2	5-3	5
XMIT UCN EAM	3.6	4-3	5	3.8	4-3	5
XMIT ECN WB	4.8	5-4	5	4.4	5-4	5
XMIT ECN OW	4.8	5-4	5	4.4	5-4	5
XMIT FN	5.0	--	5	4.4	5-4	5
XMIT FN EAM	5.0	--	5	4.4	5-4	5
CP to ACP	4.8	5-4	5	4.2	5-3	5
MPU restart	5.0	--	5	4.8	5-4	4
Equipment set up--ACP	5.0	--	4	4.2	5-4	5
Parameter entry--ACP	4.8	5-4	5	4.2	5-4	5
Satellite commands	3.8	5-3	5	4.2	5-3	5
ACP to CP	4.8	5-4	5	4.2	5-4	5
Change satellites	4.4	5-4	5	4.4	5-4	5
USAFE						
Equipment set up--CP	4.1	5-4	7	2.4	3-1	7
Parameter entry--CP	4.0	5-3	7	2.7	4-1	7
Initialize MPU	4.6	5-4	9	3.4	4-2	9
XMIT UCN	4.2	5-3	9	3.2	5-1	9
XMIT UCN EAM	3.9	5-3	9	3.0	4-1	9
XMIT ECN WB	4.1	5-4	9	3.2	4-1	9
XMIT ECN OW	4.2	5-4	9	3.1	4-1	9
XMIT FN	4.3	5-3	9	3.3	4-1	9
XMIT FN EAM	4.1	5-3	8	3.3	4-1	8
CP to ACP	4.1	5-4	9	3.2	4-1	9
MPU restart	4.1	5-4	7	3.3	4-1	6
Equipment set up--ACP	4.0	5-3	8	3.0	4-1	8
Parameter entry--ACP	4.0	5-3	8	3.0	4-1	8
Satellite commands	3.6	5-3	8	3.0	4-1	8
ACP to CP	4.0	5-4	8	3.1	5-1	8
Change satellites	3.7	5-3	7	2.9	4-1	7

NOTE: Ratings based on 5-point scale with 5 being very easy or very adequate and 1 being very difficult or very inadequate.

TABLE A-2. MAINTAINER RATINGS OF TASKS PERFORMED

Maintainer task	Ease of performance			Adequacy of tools and test equipment			Adequacy of manuals		
	Mean	Range	No	Mean	Range	No	Mean	Range	No
Performance tests									
WB medium loop	4.7	5-4	6	a	--	--	4.2	5-4	6
CN NB medium loop	4.3	5-3	6	a	--	--	4.2	5-4	6
1 MHz freq std	4.3	5-4	6	4.0	5-3	6	3.8	4-3	6
CN NB signal output	3.7	5-3	6	4.2	5-3	6	3.2	5-2	6
CN NB dnlk freq	3.6	5-3	5	4.0	5-3	5	3.6	4-3	5
Receiver sys gain	4.0	5-3	6	4.0	5-3	6	3.8	5-3	6
Receiver sys noise	3.8	4-3	5	3.8	4-3	5	3.6	4-3	5
CN NB char error	4.2	5-4	6	4.2	5-4	6	4.0	5-3	6
WB char error	4.2	5-4	6	a	--	--	4.0	5-3	6
WB full loop	4.3	5-4	6	a	--	--	3.8	5-3	6
CN NB full loop	4.3	5-4	6	a	--	--	4.2	5-4	6
CN NB OW full loop	4.2	5-3	6	a	--	--	4.2	5-4	6
Troubleshooting procedures									
System faults	3.5	4-2	6	3.8	4-3	6	2.4	4-1	5
Power distribution	4.0	5-3	5	4.2	5-4	5	3.4	4-2	5
FN 12 db atten	4.0	4-4	4	4.3	5-4	2	3.5	4-3	4
Antenna interface	3.3	4-3	4	4.3	5-4	4	3.5	4-3	4
Antenna	4.0	4-4	2	1.5	2-1	2	3.5	4-3	2
Remove and replace procedures									
Antenna	4.8	5-4	6	a	--	--	3.2	4-1	6

NOTE: Ratings based on 5-point scale with 5 being very easy or very adequate and 1 being very difficult or very inadequate.

^aNo tools or test equipment necessary.

IV. Observations concerning operator log entries are as follows:

- a. Typed log at USEUCOM was mostly unreadable.
- b. USAFE only maintained a partial log.
- c. Neither log had entries pertaining to which channels were in use.
- d. Neither log had indications of what operator action occurred following receipt of an emergency action message (EAM).
- e. Neither log had entries when synchronizer code was sent to force terminals.
- f. USEUCOM logged only 48 percent of their 103 transmitted messages while USAFE logged 14 percent of 35 transmitted messages.
- g. USEUCOM logged only 46 percent of 479 messages received while USAFE logged only 4 percent of 120 messages.
- h. When messages were logged, the entries were often incomplete (for example, missing date time group and subject).
- i. USEUCOM logged 83 percent of 41 received Joint Chiefs of Staff (JCS) EAM's while USAFE logged only 1 of 33.
- j. USEUCOM only logged information concerning EAM acknowledgments one of five times, USAFE zero of three times.
- k. USEUCOM only logged five of eight times that they passed control of the force net to USAFE; USAFE was zero for two.
- l. USAFE did not make log entries indicating when maintenance was performed on the system.

V. Observations of operational procedures not in compliance with the CEOI are as follows:

- a. At both sites, the operators did not know which force terminals, if any, were supposed to be in a "Run Silent" status.
- b. AT both sites, the AN/GSC-40 operators did not follow CEOI procedures for entering and removing force terminals on the net.
- c. No operator at either site followed the CEOI for message format.
- d. Neither site sent updated network status reports to the airborne command post.
- e. USAFE never sent out the time synchronization message to the force net.

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- d. Neither site sent updated network status reports to the airborne command post.
- e. USAFE never sent out the time synchronization message to the force net.

f. USEUCOM and USAFE did not follow CEOI procedures when they passed control of the net from one site to the other. Their biggest omission was not giving the site assuming control an update on network member status.

g. USAFE and USEUCOM did not follow procedures while performing a satellite changeover.

(1) USEUCOM did not give USAFE any advance warning to change satellites.

(2) USAFE made the change without informing the net and consequently the command post was on one satellite while the rest of the net was on the other satellite. Twelve minutes later they corrected the problem.

(3) The procedure for changing back to the primary satellite went more smoothly.

h. At both sites, operators failed to inform the watch officer when force terminals did not acknowledge EAM's.

VI. Findings concerning safety warnings for lifting equipment are in Table A-3.

TABLE A-3. SAFETY WARNINGS FOR LIFTING EQUIPMENT

Type equipment	No of units	Wt (lbs)	Lift height (ft)	Type of warning label required for different maintenance teams			People required per current manual (no)
				Team one ^a	Team two ^b	Team three ^c	
Diplexer	2	47	5	2-man	2-man	mech	2
Centrifugal blower (RK 3 & 4)	2	50	2	d	d	d	2
Computer	1	50	2	d	d	d	2
MPU	1	50	2	d	d	d	2
FN RT's	3	50	5	2-man	2-man	2-man	2
Antenna coupler	2	60	3	a	2-man	2-man	2
Centrifugal blower (RK 1 & 2)	2	72	2	d	2-man	2-man	2
28Vdc pwr (RK 6 & 8)	2	72	1	d	2-man	2-man	2
Antenna drive	2	83	3	2-man	2-man	2-man	2
Printer	2	95	3	2-man	2-man	mech	2
Antenna	2	100	5	mech	mech	mech	2
KDU	2	144	3	mech	mech	mech	3
28Vdc pwr (RK 1, 2, 4, 5)	4	175	1	mech	mech	mech	e

NOTE: All lift restrictions on equipment need to specify the restriction (2-man or mechanical) and the weight of the unit.

^aA male maintainer with male or female assistance available.

^bA female maintainer with male assistance available.

^cA female maintainer with female assistance available.

^dNo warning required.

^eOnly states "Need assistance."