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Working Paper

SINGLE CHANNEL GROUND AND AIRBORNE RADIO SYSTEM:

MANPRINT EVALUATION OF EASE OF OPERATION

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FOREWORD

This report presents the results of an ARI evaluation of MANPRINT aspects of the Single Channel Ground and Airborne Radio System (SINCGARS) during the Follow-on Test and Evaluation (FOTE) conducted by the U.S. Army Test and Experimentation Command (TEXCOM), Fort Hood, Texas. The FOTE was conducted during April and May of 1988 at Fort Sill, Oklahoma. The material in this report was incorporated in the TEXCOM Test Report on SINCGARS submitted on the U.S. Army Operational Test and Evaluation Agency (OTEA), Falls Church, Virginia.

SINGLE CHANNEL GROUND AND AIRBORNE RADIO SYSTEM:
MANPRINT EVALUATION OF EASE OF OPERATION

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BACKGROUND

The SINCGARS FOTE issue of whether the SINCGARS radio provides sufficient ease of operation to enable the operator to effectively perform the mission under tactical conditions incorporates as major concerns: the manpack configuration, operator response to jamming, operation under MOPP-IV conditions, and general operator problems. The manpack sub-issue addresses the portability of the SINCGARS radio in the manpack configuration and concerns how the portaged radio influences physical activities of the operator-soldier such as running, aiming, and mock-firing the M16 rifle from the prone position and carrying combat gear. The MOPP-IV sub-issue addresses the ease of operating all configurations of SINCGARS (manpack and vehicular) in mission-oriented protective posture (MOPP). This MOPP condition requires the soldier to wear protective gloves and hood. The sub-issue of operator response to jamming addresses concerns that the SINCGARS operator must be able to recognize jamming and take appropriate operational steps in response to preserve communications. General operator problems, as a sub-issue, addresses generic concerns for identifying any problems associated with the radio or its operation which may degrade operator performance.

DESCRIPTION

The SINCGARS family of receiver-transmitters (RT) allows single channel (SC) FM operation in the VHF band (30-87.975 MHz), frequency hopping (FH) for ECCM operation, eight preset channels for the SC mode and six for the FH mode, built-in self-tests (BIT), and the capability of voice and digital data communication. There are seven configurations of SINCGARS, six of which are vehicular (AN/VRC-87 through AN/VRC-92). The major differences among these vehicular configurations are range capabilities and dismountable opportunities.

The SINCGARS AN/PRC-119 is the manpack configuration of the radio which relies on a 13.5 volt lithium battery for power. It has the same physical characteristics as the AN/VRC-87 through AN/VRC-92 with which components are interchangeable. The major difference between the AN/PRC-119 and other configurations, beyond mounting, is of transmission distance and power output: the manpack configuration is limited to 4 watts output (high power) while vehicular configurations can produce 50 watts output (power amplifier). The manpack configuration requires a number of components besides the receiver-transmitter to be operational: manpack antenna (AS-3683/PRC), battery box (CY-8346/PRC), handset (H-250/U), and battery (BA-5512/U). For secure operation, as with vehicular configurations, a TSEC/KY-57 (VINSON) and CX-13293/VRC cable is required. Total weight of the manpack-configured RT is 15.8 pounds, to which must be added weights of the battery, VINSON, and handset. In addition to the RT and assembled components, the prescribed manpack configuration requires use of a backpack shelf (2 pounds) mounted on a pack frame and harness and secured by tiedown straps.

REPORT FORMAT

This report addresses the SINCGARS operability issue in four sections (sub-issues): a) manpack portability; b) MOPP-IV operating condition; c) response to jamming; and d) general MANPRINT concerns. Each section is divided into subsections which present: a) evaluation methodology; b) findings; and c) conclusions and recommendations. Figures 1 through 3 provide an indication of data collection schedules and efforts.

MANPRINT OPERATIONS ORDER #2

Date of Issue: 19 April 88
Period: 19-22 April 88
Event: FOTE Phase 1

Mission 1: Collect MOPP-IV data (Section 2)
- 19 April - 2000-2200
- 20 April - 1000-1200, 2000-2200
- 21 April - 2000-2200
- Note: Need for collection of 10 or > observations.

Mission 2: Collect jamming response data (Section 1)
- 19 April - 1900-2200 (FH-S) + heliborne 1000-1100
- 20 April - 0500-0800 (FH-S), 1100-1300 (SC-S/SC-NS), 1400-1600, 1700-1800 (FH-NS)
- 21 April - 2100-2400 (FH-S)
- 22 April - 0100-0300
- Note: Need for collection of 15 or > observations.

Mission 3: Collect backpack data (Section 3)
- 19 April - 1000-1800, 2000-2400
- 20 April - 0600-0800, 2200-2400
- 21 April - 0001-0800, 1000-1800, 2200-2400
- 22 April - 0001-0300
- Note: Need for collection of 15 or > observations.

Mission 4: Special interest data (Section 4)
- NCS problems and operations
- Use of whisper
- Configuration of backpack
- Visibility of controls at night
- Availability of manuals

Figure 1. FOTE Phase 1 MANPRINT data collection directive.

MANPRINT OPERATIONS ORDER #3

Date of Issue: 26 April 88
Period: 26-30 April 88
Event: FOTE Phase 1

Mission 1: Collect MOPP-IV data (Section 2)
26 April - 0800-1000, 2000-2200
27 April - 2000-2200
28 April - 2000-2200
Mission 2: Collect jamming response data (Section 1)
26 April - 1100-1200, 1300-1800
27 April - 0500-0800, 1100-1300, 1400-1500, 2000-2200, 2300-2400
28 April - 0100-0300. 1100-1800
Mission 3: Collect backpack data (Section 3)
26 April - 1100-1800, 2000-2400
27 April - 0001-0500, 1000-1600
28 April - 0300-0800, 1200-1800
Mission 4: Special interest data (Section 4)
Determine if backpack whisper mode operates
Configuration loudness of SINCGARS

Figure 2. FOTE Phase 2 MANPRINT data collection directive.

MANPRINT OPERATIONS ORDER #4

Date of Issue: 1 May 88
Period: 2-6 May April 88
Event: FOTE Phase 1

Mission 1: Collect MOPP-IV data (Section 2)
2 May - 2000-2200
3 May - 2000-2200
4 May - 2000-2200
Mission 2: Collect jamming response data (Section 1)
2 May - 1500-1800, 2000-2200
3 May - 0900-1300, 1400-1500, 1600-1700, 2000-2400
4 May - 0100-0200, 0530-0630, 1300-1400, 1500-1600, 2000-2400
Mission 3: Collect backpack data (Section 3)
2 May - 2000-2200
3 May - 1000-1800
4 May - 1200-1800
Mission 4: Special interest data (Section 4)
Observation of backpack configuration/use
Encourage use of backpacks
Visit OPFOR (prep for Mon 1330 and Tues 0930 air asslt)
Mission 5: MANPRINT Final Thrust
5 May - 0900-1800 Backpack physical testing (B Co)
6 May - 1300-1400 Assist in administering DC 16 (Snow Hall)
9 May - TBD by units - Assist in administering final evaluations

Figure 3. FOTE Phase 3 MANPRINT data collection directive.

EVALUATION METHODOLOGY (Manpack)

Two methods of data collection were employed to support the MANPRINT evaluation of the SINCGARS manpack portability and ease of operation. These two strategies, observation and interview and experimentation, are separately addressed below. Two additional methods, questionnaire (problem checklist) and daily problem logs filled out in the field, while more generic in orientation, also provided information on the manpack. These findings are reported elsewhere (Tables 8, 9 and 10) in this report.

Observation and Interview. Three officers, trained by an ARI research psychologist as MANPRINT observers and data collectors, provided observational and directed interview data on manpack use and operations. Phase-specific MANPRINT Operations Orders guided these data collection efforts (see Figures 1 through 3). A specially designed form (MANPRINT Special Operations Data - Section 3: Operations with Backpack, and Section 4: General Observation) was used to record and report manpack data. These discrete observational reports were obtained during test unit tactical use of manpack SINCGARS, and additional observations were obtained during the manpack physical performance testing and experimentation. MANPRINT data collectors also recorded soldier comments during field interviews of manpack operators. A number of related and additional problem-oriented observations were provided by operators responding to specific items on the Operational Problem Debriefing Form (DC Form 16) administered at the end of the FOTE and by operator self-reports on MANPRINT Problem Logs (DC Form 15) completed daily during the FOTE.

Experimentation. Eight soldiers, all with 11B MOSs, obtained from the test unit participated in a physical performance controlled experiment conducted by an ARI research psychologist and two of the three officers trained as MANPRINT data collectors and observers. This testing involved three samples of a soldier's movement mission: 60m run, 20m run-prone-aim-fire, and 6m low crawl. Each soldier was required to perform each task once while wearing the SINCGARS manpack (including VINSON) and once without the manpack. Under both conditions, soldiers carried their basic combat gear excluding rucksacks. The order of testing conditions within each task sample was counterbalanced, and a minimum of 20 minutes rest between individual efforts was allowed. Within each mission task, all soldiers used the same test course, and all testing was done on an individual basis. During this testing, additional observations on manpack MANPRINT concerns were made.

FINDINGS (Manpack)

Table 1 records the nature and number of observation and interview data collection efforts during the FOTE by the three MANPRINT data collectors. Table 2 provides a summary of observational and interview data specific to the manpack configuration and operation contributed by MANPRINT data collectors and an ARI research psychologist.

Table 1

MANPRINT Special Operations Comments

Operation	Phase 1		Phase 2		Phase 3		Total
	Intv	Obsr	Intv	Obsr	Intv	Obsr	
Response to Jamming	7	9	2	3	0	4	25
MOPP-IV Operations	3	4	4	0	0	0	11
Backpack Operations	8	0	7	0	0	0	15
General	36	4	34	1	3	3	81
Total	54	17	47	4	3	7	132

Table 2

SINCGARS Manpack Observational Data

Observation	MANPRINT Domain*
Operator is unable to raise head in prone position due to pack frame	S HFE
Operator's helmet pushes forward in prone position to block sighting of M16	HFE
Manpack is criticized as too heavy	HFE S
Manpack is uncomfortable due to low-hanging shelf	HFE S
Configuration of manpack requires too much time (15-20 min)	HFE
Attaching cabling to connectors is difficult	HFE
Cabling too frequently comes loose or off-- particularly VINSON	T HFE
Pins connecting battery to RT bend too easily	HFE
Knobs are prone to accidental movement when going through heavy vegetation	HFE
Manpack shelf is perceived as too fragile	HFE
Cabling is prone to getting tangled with vegetation	HFE
Battery life is too short	HFE

*S = safety, HFE = human factors engineering, T = training

Additional operator comments germane to the manpack as well as other configurations were obtained from daily collection of MANPRINT Problem Logs (DC Form 15) and completion at the end of the FOTE of the Operational Problem Debriefing (DC Form 16). These comments are reported in Table 8, 9, and 10.

The manpack mission performance testing involved experimentation under relatively controlled conditions and provided quantitative data. Sample characteristics of soldier participants in this testing are described in Table 3. For all anthropometric measures, soldiers were fully clothed and

length measurements were operationally defined: arm length was from collarbone to knuckle; waist was circumference above hip bone; shoulder width was from lateral collarbone to lateral collarbone; leg length was from dorsal hip bone to bottom of boot heel.

Table 3

Manpack-Mission Performance Sample

Physical Characteristics	Number	Mean	Range
Age (years)	8	22.9	19-33
Height (inches)	8	70.1	66-74
Weight (pounds)	8	174	149-198
Arm Length (inches)	8	29.2	25-26.8
Waist (inches)	8	33.7	29-36.5
Shoulder Width (inches)	8	17.8	16.5-18.5
Leg Length (inches)	8	41.4	39.5-45
Dominant Hand	8	N/A	7(R), 1(L)
Body Type	8	N/A	7 Mesomorph 1 Ectomorph
Medical History	**Number**	**Mean**	**Range**
Time Since Last Physical (years)	8	2.2	1-5
Broken Bones	8	N/A	5(Y), 3(N)
Torn Muscles	8	N/A	3(Y), 5(N)
Medication Status	8	N/A	8(N)
Military Characteristics	**Number**	**Mean**	**Range**
Rank	8	N/A	E-2 to E-7
Time in Service (months)	8	38	8-156
Last M16 Qualification (months)	8	3	0

Soldier mission task performance measured under manpack and no-manpack conditions involved four dependent variables: systolic and diastolic blood pressures, pulse rate, and task completion time. These data are reported in Table 4. The low crawl with manpack task was canceled for safety considerations: while in the prone (start) position, it was clearly determined that the pack frame severely restricted head movement and that body gyrations would cause undue pressure and pounding at the base of the skull. The cancelation of the low crawl with manpack, necessary to avoid a definitive safety and health hazard, precluded the need to test low crawl without manpack.

Table 4

Manpack-Mission Performance (DC Form 18) Data Summary

Condition	Blood Pressure		Pulse Rate	Time*
	Systolic	Diastolic		
60 Meter Run with Manpack	191	83	113	11.60
60 Meter Run without Manpack	177	76	103	10.55
20 Meter Run-Prone-Aim-Fire with Manpack	149	79	81	8.31
20 Meter Run-Prone-Aim-Fire without Manpack	142	83	85	7.56
6 Meter Low Crawl with Manpack	(canceled due to safety hazard)			
6 Meter Low Crawl without Manpack	(no comparative requirement)			

*in seconds

The descriptive data of Table 4 were statistically tested to determine physiological and performance effects of the manpack. Each dependent variable score for the manpack condition of a task was compared to its counterpart for the without-manpack condition by a correlated one-tail "t" test (df=7). A significant ($p<.05$) t value suggests that addition of the manpack to the soldier's load produced an appreciable physiological response or degradation of performance. Based on these analyses, the following manpack effects emerged:

a. Significant time increase for the 60m run ($t = 4.34$);

b. Significant time increase for the 20m run-prone-aim-fire ($t = 2.71$).

Of related note, data provided by DC Form 16 indicated that 50% of soldiers who carried a manpack during the FOTE experienced fatigue, soreness, injury, or discomfort.

CONCLUSIONS AND RECOMMENDATIONS (Manpack)

SINCGARS manpack findings of the three MANPRINT data collectors and an ARI research psychologist (Table 2 and 4), reported as interviews or observations, were strongly supported by operator reports (Table 8, 9 and 10). Based on combined data, the following conclusions are provided:

- The manpack configuration, due to the pack frame, is a safety hazard while going to or moving in the prone position. The pack frame should be redesigned so that the top (anterior) end is at least 1"-2" shorter, the top crossmember is concave relative to the neck, and the upper portions of sides curve away from the back.

- Soldiers wearing manpacks are restricted in their ability to sight and/or fire an M16 due to the pack frame pushing the helmet down over their eyes and hampering head movement. Pack frames should be redesigned.

- o Manpacks are uncomfortable and unwieldy, particularly when trying to sit or squat, due to the VINSON shelf extending down the lower (lumbar) back. The bottom shelf should be eliminated and some other arrangement of the VINSON considered.

- o The cable-connector interface is difficult and leads to loose and broken connections which interfere with maintenance of communications. Consideration should be given to redesigning connectors.

- o Exposed cables and RT controls are prone to damage or alteration of settings by contact with vegetation. A possible solution would be canvas flaps which would cover cabling and the RT face.

- o Battery life (real or doctrinal), replacement, and complications of having to carry spares are problems. Batteries should meet the capabilities stated in TM 11-5820-890-10-1 and should have a strengthened interface (pins) with the RT. Latches connecting the battery box and RT are difficult to operate, often requiring use of a tool, and should be redesigned.

- o There would be incompatibility problems if the rucksack and SINCGARS manpack were configured on the same pack frame. The rucksack would likely have to be repacked and worn higher on the frame than desirable, which would severely restrict access to controls, or worn strapped dorsally to the RT, which would likely imbalance the soldier.

- o The manpack test revealed that addition of the manpack to the soldier's load resulted in performance (run time) decrements but carried no appreciable physiological consequence. The question remains open as to how this compares to effects of carrying the current radio (PRC-77).

EVALUATION METHODOLOGY (MOPP-IV)

Data addressing concerns for operating SINCGARS under MOPP-IV conditions were collected by three officers trained as MANPRINT data collectors and observers. These individuals collectively spent approximately 250 man/hours in the field with test units during the FOTE, to include scheduled periods of MOPP conditions. The primary source of data on MOPP-IV effects on radio operation was observation and interview. Additional data, though representing a much broader spectrum of concerns, was obtained from soldier-operator daily self-reports (DC Form 15).

Observation and Interview. MANPRINT data collectors recorded observations and MOPP condition-specific interviews of operators on the MANPRINT Special Operations Data form (Section 2: Operations in MOPP Condition and Section 4: General Observation). Scenarios from each FOTE phase indicated specific times test units would operate under MOPP conditions, and MANPRINT data collectors were assigned observational times to respect these "windows." The MANPRINT Operations Orders for each FOTE phase, presented as Figures 1

through 3, indicated programmed "windows" of opportunities for relevant data collection efforts. A number of MOPP-related problems were also reported by operators on MANPRINT Problem Logs (DC Form 15) completed daily during the FOTE.

FINDINGS (MOPP-IV)

Table 1 records the nature and number of observation and interview data collection efforts during the FOTE by the MANPRINT data collectors. Table 5 provides a summary of observational and interview data specific to problems encountered when operating SINCGARS under a MOPP-IV condition. This table includes MOPP-related problems recorded in Table 8. Of note, over 80% of the observations and interviews of soldier-operators indicated an absence of any particular problem.

Table 5

SINCGARS Operation During MOPP Observational Data

Observation	N	MANPRINT Domain*
No problem	10	N/A
Conversation clarity suffers	2	HFE
Removal of gloves when troubleshooting	1	HFE
Difficulty in seeing keypad	1	HFE
Poor visibility of controls**	3	HFE
Difficulty using keypad (gloves)**	6	HFE

* HFE = human factors engineering
** Self-reported (Table 8)

CONCLUSIONS AND RECOMMENDATIONS (MOPP-IV)

SINCGARS MOPP-IV operation findings by the three MANPRINT data collectors (Table 5), reported as interviews and/or observations, revealed a minimal number of operator problems specific to the MOPP condition. It was also noted through operator self-reports (Table 8) that MOPP-related problems reported were also typically indicated as generic to the radio under any operational condition, though particularly night operation. Based on available data (Table 5 and 8), the following conclusions are provided:

- A sizable majority of soldiers sampled indicated no condition-specific problems in operating the radio under a MOPP-IV condition.
- The visibility of controls while in MOPP was seen as a problem. However, the same problem was also reported for night conditions and appears to be a generic problem under any condition of restricted light or visual angles.

- o The ability to effectively utilize the keypad (entry of numbers and commands) appears degraded while operating in a MOPP-IV condition due to the gloves. Larger keys and more separation between them could reduce this problem.

EVALUATION METHODOLOGY (Jamming)

Two methods of data collection were employed to support the MANPRINT evaluation of soldier-operator response to jamming. These strategies, a) observation and interview and b) questionnaire, are separately addressed below. It must be appreciated that any evaluation of operator response to jamming presupposes that: a) operators recognized jamming, and b) the jamming was sufficiently effective so as to degrade communications and thereby stimulate some responsive act. The two data collection techniques, respecting these presuppositions, entailed somewhat different orientations. Of note, neither operator training nor TM 11-5820-890-10-1 dealt specifically with recognition of or response to jamming.

Observation and Interview. Three officers, trained as MANPRINT data collectors and observers, provided observational and directed interview data on operators' response to jamming. The MANPRINT Special Operations Data (Section 1: Response to Jamming and Section 4: General Observation) form was used to record and report relevant data. Data collectors were made aware, based on scenarios from each FOTE phase, of the times and sources (ground or airborne) of planned jamming and were assigned observational times to respect these "windows." Figures 1 through 3 reflect the MANPRINT Operations Orders which guided relevant data collection efforts. Few jamming-related problems were reported by operators on MANPRINT Problems Logs (DC Form 15) completed daily during the FOTE.

Questionnaire. A problem-oriented questionnaire, the Operational Problem Debriefing Form (DC Form 16), was developed to tap general problems which may have been experienced operating the SINCGARS radio. Many items in this instrument evolved from the content of MANPRINT Problem Logs (DC For 15) which were completed daily. The questionnaire was administered to all operators and data collectors at the end of the FOTE. This instrument assessed the nature and frequency of problems spanning MANPRINT domains, as may be seen in Table 9 and 10, though one item specifically referred to the recognition of jamming.

FINDINGS (Jamming)

Table 1 depicts the nature and number of MANPRINT data collector observations and interviews relative to jamming. A number of entries in the "General" category were devoted to jamming, with most indicating the continuation or only minimal interruption of communications in the absence of any anti-jamming efforts. Table 6 provides a summary of observational and interview data specific to jamming.

Table 6

SINCGARS Operator Jamming Response Observational Data

Specific Observations (N = 25)	Percent	MANPRINT Domain*
Operator experienced no indications of jamming	52%	N/A
Operator gave no indication of suspecting jamming	12%	T
Operator indicated suspicion of jamming:	36%	T
Did nothing	11%	
Reported/sought advice	22%	
Performed tests for jamming	0%	
Used one or more anti-jam steps	44%	
Other (keyed handset twice)	22%	
General Observations (N = 10)	**Percent**	**MANPRINT Domain***
Experienced jamming usually results in increasing power to PA and/or going to FH mode	20%	T
Many experienced jamming but could still get through (with distortion)	20%	T
Jamming was not experienced	60%	N/A

*T = training

Based on operator self-reports (DC Form 15) as listed in Table 8, the largest number of specific training problems mentioned by soldiers involved the need for training in recognizing and responding to jamming (N = 11). On the Operational Problem Debriefing Form (DC Form 16), 69 % of operators reported attempts to recognize jamming, and of these, 74% problems in this area.

CONCLUSIONS AND RECOMMENDATIONS (Jamming)

Based on the data provided in observations and interviews by MANPRINT data collectors (Table 6) and information provided by both operators and data collectors (DC Form 15 and 16), the following conclusions are offered:

- The training manual and SINCGARS operator course did not address response to jamming (anti-jamming steps). Both performance data (Table 6) and expressed problems by operators verify the need for pointed training and reference resources in this area.

- 50%-60% of the operators surveyed experience jamming-based disruption of communications.

- o The typical response to recognized jamming appears to be to do nothing if disruption is not severe or to increase power output. These responses are not necessarily beneficial, as both could result in degraded communications (increased power could produce interference).

- o Nearly 75% of operators who attempted to recognize jammng reported problems. Failure to adequately train in this area could produce unwarranted numbers of problems (overload) reported to the maintenance (31V and 29E) system with manpower and equipment availability repercussions.

EVALUATION METHODOLOGY (General)

The general MANPRINT evaluation of SINCGARS radios and operator-experienced problems considered all domains of MANPRINT, all ground configurations of the radio, and several pieces of attached (interoperable) equipment. It did not directly address the three problem areas already discussed (i.e., manpack, MOPP-IV, and jamming). This evaluation relied on input from the following sources: MANPRINT data collectors (three officers), test unit radio operators, data collectors, and an ARI research psychologist. Data collection occurred during each phase of the FOTE on a daily basis and at the end of the FOTE. Three primary data collection strategies employed were a) observation and interview, b) operator self-report, and c) questionnaire. Each is addressed separately below.

Observation and Interview. Three officers, trained as MANPRINT data collectors, and one research psychologist collected data in the field on a daily basis throughout the FOTE. These specialized data collectors provided observational and directed interview data on specific research interests (see Figures 1 throught 3) and on other MANPRINT-related concerns. Data was recorded on the MANPRINT Special Operations Data form (Section 4: General Observation). The quantity of data obtained in this manner is recorded in Table 1.

Self-Report. Data collectors, assigned to monitor each operator, reported MANPRINT data on the MANPRINT Problem Log (DC Form 15). A data form was required every 12 hours covering each operator, and this form was essentially unstructured to allow maximum freedom of response content and style. All data collectors received a one hour block of instruction during data collector training from an ARI research psychologist. This training familiarized data collectors with the nature, content, and concerns within each MANPRINT domain, provided examples of previous findings, and instructed on the use of DC Form 15.

Questionnaire. The Operational Problem Debriefing Form (DC Form 16) was configured to allow a comprehensive, experience-based (end of FOTE) assessment of problems encountered in operating the radio. The instrument allowed for responses in three domains: a) problems experienced based on specific tasks, b) problems experienced based on specific conditions, and c) potential interface between training and problems experienced. The general format for

the first two domains was a checklist, while that for the third domain was of listing or short answer. All operators and data collectors were requested to complete DC Form 16.

FINDINGS (General)

Table 7 presents information either provided to or provided by MANPRINT data collectors which was in addition to condition-specific (manpack, MOPP, jamming) reported in other section of this report. Many of these data relate to interoperability concerns with SINCGARS, and particularly of artillery equipment that interfaces with SINCGARS. Table 8 provides problems or observations, by FOTE phase, reported by SINCGARS operators. There were 749 MANPRINT Problems Logs returned during the FOTE (approximately 55% return rate). These forms yielded 816 readable comments. These data were collected on a twice daily basis and include some findings which were also included in condition-specific sections of this report.

Table 7

General Observational Comments by MANPRINT Data Collectors

Domain	Problem Nature	Frequency
Human Factors	RT has too many switch settings--increases opportunity for error	1
	Locking bars for top RT in multiple configurations fail to actually secure RT	1
	Antenna is not perceived as durable	2
	CVC problems: hearing or malfunctioning	3
	Cold start procedures too lengthy	1
	Control labels difficult to see in dim lighting; illumination required in dark	2
	Cabling too short or difficult in tank	2
	Problem in seeing display (angle) in tanks; need mirrors or prism	3
	Accidental movement of function knob to Z-A, particularly at night	2
	VINSON cable comes loose causing loss of commo	1
	Digital net produces too loud of a noise	1
	Digital drowns out voice on speaker with multiple RTs	2
	Battery and VINSON cable pins bend	2
	Other	3
Equipment	Clock drift causing loss of time synchronization	1
	Co-site interference of multiple antennas in retrans	1
	Battery boxes crack and short out RT; new battery boxes short out RT	2
	Bleeding on digital nets	1
	Difficult to maintain BCS commo; possibly due to BPS	2

Table 7 cont.

Domain	Problem Nature	Frequency
Equipment (cont.)	Maintaining digital commo difficult in single channel--seems to require more power	3
	Need to determine and standardize best DMD preamble to interface with RT or net	3
Training	20% of operators did not have a manual	2
	Problem in understanding use of "magic cable" for DMD interface	2
	Vehicles often left antennas tied down possibly reducing commo	3
	Failure to understand LOS requirement	2
	Need training in loading time	1
	DMD troubleshooting practices poor	1
Other	No problems with commo; clear and no garble	6

Table 8

MANPRINT Problem Log (DC Form 15) Comments

Domain	Problem Nature	Phase 1	Phase 2	Phase 3	Total
Human Factors	Keypad lighting need	13	2	7	22
	RT or net start-up time (length)	1	0	1	2
	Battery installation	1	1	2	4
	Panel lighting need	7	2	5	14
	VINSON cable connection	5	2	6	13
	Display visible (angles)	8	2	4	14
	Knob size or type	1	0	3	4
	Power cable connection	1	3	1	5
	Backpack or frame configuration	2	5	4	11
	Keypad use with gloves	4	1	1	6
	Configuring backpack from vehicle	0	3	1	4
	Visibility of controls in MOPP	1	2	0	3
	Antenna cable connection	6	4	1	11
	RT configuration in M151	5	3	1	9
	Handset or audio cable connection	5	3	2	10
	Cable or connector quality	1	2	1	4
	Volume (inadequate) when moving	4	2	0	6
	Multiple RTs on one speaker	7	0	0	7
	Accidental zeroing of RT	1	1	0	2

Table 8 cont.

Domain	Problem Nature	Phase 1	Phase 2	Phase 3	Total
Human Factors (cont.)	VINSON cable loosening	6	3	0	9
	Handset quality (sturdiness)	3	0	0	3
	General complexity of procedures	1	3	0	4
	Antenna breakage	2	1	1	4
	Control knob breakage or removal	0	0	2	2
	Provision for carrying batteries	0	1	1	2
	Backpack shelf quality	2	0	0	2
	Other	3	0	5	8
Safety	Concern for volatile batteries	0	1	0	1
	M151 antenna proximity to person	2	2	1	5
	Backpack frame injury	1	0	1	2
Equipment	Co-site interference	3	2	2	7
	Clock drift--holding battery	1	9	2	12
	Battery life (backpack or DMD)	4	2	1	7
	VINSON operation or malfunction	1	1	1	3
	Defective handset	2	0	1	3
	Defective or malfunctioning RT	2	0	0	2
	DMD preambles or problems	2	4	0	6
	Other	6	0	1	7
Training	Use of line-of-sight	2	5	2	9
	Troubleshooting procedures	3	1	2	6
	Operator confusion or forgetting	4	0	1	5
	Poor or insufficient training	9	1	3	13
	No possession or use of manual	2	1	2	5
	Net transfer procedures	3	0	2	5
	Loading or storing HOPSET	3	1	3	7
	Loading lockout	2	0	1	3
	Loading battery time	1	2	1	4
	Late entry procedures	4	2	1	7
	Jamming recognition or response	7	2	2	11
	Loading or synchronizing time	3	3	1	7
	Net initialization (cold or full)	3	1	3	7
	Receive or store TRANSEC variables	1	1	1	3
	Offset procedures or coordination	2	1	0	3
	Send or receive ERF procedures	3	2	2	7
	Other (cue, power, mode, scan)	5	1	3	9
Other	Nonspecific, administrative, etc.	22	14	6	42

Table 8 cont.

Domain	Problem Nature	Phase 1	Phase 2	Phase 3	Total
No comment or problem		129	129	165	423

Table 9 provides, for both operators (exclusive of NCS) and data collectors (cross-trained as operators), data from DC Form 16 which reflected what critical operator tasks were attempted and the problem rate associated with each task. These data could be used to identify "high risk" (in terms of problem probability) tasks which may need additional training or procedural (or equipment) modifications to support initiating and maintaining effective communications. This table could be used to establish a task profile for operators which could guide training curriculum design and necessary training experience. While the opportunity for cross-validation of problem frequencies exists given two sets (groups) of data in Table 9, it must be respected that data collectors were sensitized to a problem-oriented perspective by their role and training. Also, data collectors may or may not have translated "attempted", performed", and "experienced" in questionnaire instructions to "observed" which would make items appropriate for their responding. An unknown number of data collectors, though instructed to the contrary, may have performed as operators on a periodic basis.

Table 9

Operational Problem Debriefing Response: Tasks

Task	% Attempting		% Problems	
	OP*	DC*	OP	DC
Install antenna	86	32	8	9
Connect handset	89	68	11	16
Configure backpack	39	24	60	37
Check battery physical condition	51	29	--	--
Check battery time condition	63	47	--	--
Replace battery	42	22	14	12
Perform BIT (self-test)	81	57	2	5
Load single channel frequency	88	73	--	2
Load offset to frequency	73	61	4	7
Clear (from storage) a frequency	83	61	2	5
Load TRANSEC variable	78	73	11	11
Load lockout set	69	76	7	11
Load HOPSET	76	77	7	13
Open net with full load	55	64	18	17
Receive and load ERF	76	73	13	23

Table 9 Cont.

Task	% Attempting		% Problems	
	OP*	DC*	OP	DC
Send ERF	30	47	20	19
Load variable data (ECCM fill)	58	67	2	10
Send CUE		54	49	1511
Respond to CUE	53	45	5	6
Open net (cold start)	64	64	15	14
Connect KY-57 (VINSON)	79	64	31	20
Retransmit (SC mode)	46	30	3	9
Retransmit (FH mode)	49	31	6	9
Communicate in SC (non-secure)	86	80	5	7
Communicate in FH (non-secure)	85	77	11	5
Accomplish net transfer	39	53	8	11
Perform PMCS	58	24	2	--
Join net - late entry	58	65	14	16
Update/correct time of day (TOD)	68	67	10	19
Carry backpack	30	20	42	24
Use whisper	51	48	--	5
Use scan	40	35	7	4
Communicate in SC (secure)	86	81	11	3
Communicate in FH (secure)	88	84	11	2
Operate in more than one net	49	57	13	10
Send data (DMD)	65	42	8	13
Operate RT while in MOPP-IV	24	23	18	6
Recognize signs of jamming	69	74	21	27
Troubleshoot RT	45	39	9	21
Use operator's manual	60	48	5	14

*Operator (OP) N = 80; Data Collector (DC) N = 75

Table 10 presents, for both operators (exclusive of NCS) and data collectors, data from DC Form 16 which reflected on specific problems or conditions encountered in operating the radio. Findings could be used to identify the nature and/or conditions of frequently experienced problems, the resolution of which may lie in training or equipment modifications. This table could be used to establish a problems profile to alert the new operator (or maintainer) of what to expect and prepare for in normal operation of the radio.

Table 10

Operational Problem Debriefing Response: Problems

Task	% Experiencing	
	OP*	DC*
Garbled transmission	62	63
Need to repeat transmission	72	73
Wrong setting of a knob	39	40
Could not see display (day)	17	23
Could not see display (night)	22	41
Need to replace battery (run down)	21	21
Cable connection problem	52	52
Handset problem	30	35
Not able to enter net	21	15
Could not hear well (handset)	26	21
Could not hear well (speaker)	25	26
Could not hear well (CVC)	24	9
Reported "broke" radio	25	20
Turned in/exchanged radio	21	15
Couldn't read control labels (day)	9	9
Couldn't read control labels (night)	27	48
Squelch not effective	12	4
Antenna problem	25	23
BIT wrongly indicated fault	14	5
Volume not loud enough	19	13
Problems with KY-57 (VINSON)	26	22
Voices not clear (secure)	19	15
Voices not clear (non-secure)	16	15
Could not receive ERF	19	24
Received RF burn or shock	5	3
Vehicle mounting problem	26	12
Problem operating RT in MOPP-IV	14	16
Volume control moved (vibrations)	9	4
Accidental zero out (Z-A)	13	16
Clock drift	42	51
Putting backpack together	22	15
Antenna breakage	25	21
Co-site interference	16	19
Could not read key pad (day)	9	4
Could not read key pad (night)	22	48
Too many RTs on a speaker	20	31
Cable vibrates loose	30	28

*Operator (OP) N = 77; Data Collector (DC) N = 75

CONCLUSIONS AND RECOMMENDATIONS (General)

Based on the data provided in observations and interviews by MANPRINT data collectors (Table 7), information provided during the FOTE by operator self-reports (Table 8), and questionnaires completed by operators and data collectors at the end of the FOTE (Table 9 and 10), the following conclusions are offered:

- The interface between SINCGARS and DMD and BCS, in terms of preambles and BPS, is a problem area potentially causing decrements in data communications. Various data rates should be explored to optimize interoperability and doctrine for interfacing should be evolved.

- Antennas are not perceived as of adequate durability--this may have influenced the number of vehicles which kept antennas tied down, likely to the detriment of effective or optimal communications.

- Battery life (or use policy) is substandard. Batteries should be able to safely meet their 20-hour standard. The requirement to change batteries every 8 hours (often modified downward by operators) is not financially feasible (costly to unit), places a major burden on soldiers with additional weight and no provision for portage, and is a logistics problem in regards to supply stocks, resupply of field units, and disposal. A rechargeable battery should be considered.

- Locking bars for upper (dismountable) RTs, particularly in M151s and M113s, fail to actually secure radios. While generally adequate to keep RTs in place during movement, a soldier is readily capable of circumnavigating the bars as theft deterrents.

- Front panel controls and their labeling have severely reduced visibility in both dim lighting and at night. Given the large number of setting possibilities and the criticality of proper settings, it is highly important to clearly see settings. Two modifications should alleviate this problem: all knobs should have pointers, and all labels should be in phosphorescent paint or be dimmer-controlled luminescent. The use of a flashlight is not an acceptable alternative.

- Display window visibility is very restricted in angles of approach; this problem is particularly pressing in the M151 and M60 configurations which require operators to assume contorted positions to view the display. A prismatic display, particularly for M60s, might improve this situation.

- Numerous problems were reported relative to difficulty in accomplishing cable connections, with particular attention to VINSON, antenna, and audio connections. Additionally, numerous instances of VINSON connections vibrating loose (and disrupting communications) were reported; while these problems may stem from failure to properly complete initial connections, they still evidence a central fault

with connectors. Strong consideration should be given to redesign of connectors. Such as an elliptical shape (to aid grip) and an easy detent lock-on.

- The use of multiple RTs on a single speaker resulted in several problems: operator confusion when more than one RT was active, and digital traffic drowning out voice communications. There should only be one RT per speaker, and speakers should have individually adjustable volumes.

- The keypad (key labels) is very difficult to see at night. Strong consideration should be given to internal luminous lighting for each key, with light level controlled by a dimmer. The SINCGARS ABN is a good example of a "fix" for this problem. Use of a flashlight is not an acceptable alternative.

- Operators complained of too low volume, particularly in vehicles while moving. It was not determined whether SINCGARS volume was any less than that of present radio equipment.

- RT configuration in the M151 was reported as very poor from a user orientation; it requires contortions to accomplish manipulating controls or obtaining adequate viewing angles, and due to position of antenna, it may constitute a safety hazard as backseat operator could be within 20 inches of RF energy. Other possible RT placements in the M151 should be explored.

- Numerous instances of clock drift, which could cause loss of commo, were reported. While it was not determined if holding batteries or improper loading or storing of time was at fault, consideration should be given to each. Holding batteries should be checked for standards of longevity, and training of time-loading and correction should be enhanced.

- A number of operators, including retransmission, indicated their suspicions of co-site interference. As this possibility was specifically tested during Phase 3 of the FOTE, treatment of this subject is left to another test report section.

- Though operator training is addressed as a separate test issue, several operator-reported training deficits or needs surfaced in Problem Logs. The preeminently perceived instructional needs, based on experience, were in the following areas: recognition and response to jamming, understanding and use of line-of-sight, procedures for sending or receiving an ERF, accomplishing net initialization, loading or synchronizing time, accomplishing late net entry, loading or storing HOPSETs, and troubleshooting the RT. Many, if not most, of these perceived deficits in training or knowledge were confirmed by task- and problem-specific responses on a questionnaire at the end of the FOTE.

- Tasks for which appreciable numbers of soldier-operators reported problems included: configuring and carrying the backpack, opening a net, (cold start or full load) sending an ERF, connecting the KY-57, operating in a MOPP-IV condition, and recognizing jamming. There was strong confirmation in the responses of data collectors though with some indication the operators may have under-reported problems.

- Operator tasks which were identified as associated with high frequencies of problems (Table 9) should be carefully studied in terms of implications for initial and sustainment training and for equipment engineering improvements. Also, units to be fielded with SINCGARS should be provided the insight afforded by Table 9 to allow them to formulate reasonable expectations for operator performance.

- Given a list of either potential or previously reported problems, soldier-operators indicated a high frequency of experiencing the following: garbled transmissions and/or need to repeat; cable connection problems; clock drift; incorrect setting of controls; loosening of cable due to vibration; inability to read control labels, keypad, and display at night; handset problems and inability to hear adequately; antenna problems, to include breakage; and mounting problems in vehicles. High frequencies of experiencing these problems were clearly confirmed by data collectors and by other sources of data beyond the end-or FOTE Operational Debrief.

- The operator data, confirmed by data collectors, in Table 10 clearly suggest the content and pervasiveness of operator or radio problems which could be anticipated by a fielded unit if no equipment and training modifications are forthcoming. Decisions need to made as to what level of problems, with particular concern foe consequences to communications, can be accepted and what solutions are available.