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REPORT

Evaluation: Compatibility of Respiratory Protective System 21 (RESPO)

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THIS PROGRAM INVESTIGATED COMPATIBILITY ISSUES WITH RESPECT TO USING SELECTED OPTICAL AND COMMUNICATION EQUIPMENT WITH RESPIRATORY PROTECTIVE SYSTEM 21 (RESPO 21). LITERATURE SEARCHES PRODUCED DATA DESCRIBING THE SELECTED OPTICAL AND COMMUNICATIONS EQUIPMENT IN SUFFICIENT DETAIL FOR IDENTIFYING CRITICAL INTERFACE AREAS AND FOR ESTABLISHING GUIDELINES FOR DESIGN AND DEVELOPMENT OF RESPO 21. TIME AND COST LIMITATIONS PROHIBITED IDENTIFYING AND INVESTIGATING EVERY PIECE OF EQUIPMENT LIKELY TO BE USED WITH RESPO 21. HOWEVER, THE METHODOLOGY FOLLOWED IN THIS PROGRAM SHOULD PROVIDE USEFUL GUIDANCE FOR EVALUATING COMPATIBILITY IN THE EVENT THAT OTHER, SPECIFIC, EQUIPMENT IS IDENTIFIED FOR USE WITH RESPO 21.

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Evaluation: Compatibility of

Respiratory Protective System 21 (RESPO 21)

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SUMMARY

This program investigated compatibility issues with respect to using selected optical and communication equipment with Respiratory Protective System 21 (RESPO 21). Literature searches produced data describing the selected optical and communications equipment in sufficient detail for identifying critical interface areas and for establishing guidelines for design and development of RESPO 21. Time and cost limitations prohibited identifying and investigating every piece of equipment likely to be used with RESPO 21. However, the methodology followed in this program should provide useful guidance for evaluating compatibility in the event that other, specific, equipment is identified for use with RESPO 21.

INTRODUCTION

The Chemical Research, Development and Engineering Center (CRDEC) is developing the next generation of respiratory protective equipment (RESPO 21) to replace the current M40-series protective masks. One of the primary goals of this system is either to integrate or to be compatible with current and future equipment on the battlefield. This equipment must be identified, and RESPO 21 design concepts must be interfaced with this equipment or with similar items that represent worst-case compatibility problems.

Background

The concept underlying this task was the need to identify and describe potential and probable compatibility requirements and problems arising from introducing RESPO 21 into the store of personal masks and hoods available for protecting armed forces personnel on the NBC battlefield. This concept ideally would encompass interfacing RESPO 21 with all equipment used on current battlefields as well as with all equipment that could reasonably be foreseen for use on future battlefields. Such a broad concept could not be adequately addressed with the time and funds available to this task, particularly as neither RESPO 21 nor future battlefield equipment have been concretely defined. Consequently, CRDEC and Battelle personnel met to select categories of equipment to be considered for compatibility studies. As a result of this meeting, communication equipment and optical equipment were selected as the broad categories of greatest interest. From the category of communication equipment, CRDEC requested that Battelle "examine" all communication equipment commonly used for field communication as well as communication equipment used in military vehicles, such as tanks. From the category of optical equipment, CRDEC requested that Battelle "examine" all optical equipment, giving special consideration to night vision systems. The goal in Battelle's reviewing both categories of equipment was to develop information that could be applied to specifying a "design envelope" for RESPO 21. This design envelope would provide insight and guidance for designing and developing RESPO 21 concepts, particularly with respect to physical and operational interfaces with communication and optical devices.

Objective

The objectives of this task were to evaluate the compatibility of RESPO 21 with current and future equipment, to identify special compatibility requirements, and to identify problem areas with respect to typical interfaces between RESPO 21 and equipment used and to be used in battlefield environments.

Scope

This task included a survey and review of communication and optical equipment that might be used by personnel wearing the RESPO 21. This effort was the basis for identifying the major design interfaces between RESPO 21 and these categories of equipment.

APPROACH

Information Collection and Review

Optical Equipment

Sources of Information. Standard searches of report documentation were made through the Tactical Technology Center and the Defense Technical Information Center. Titles, keywords, and identifiers of the holdings of these databases were searched for the key term "mask." The searches covered both classified and unclassified documents, with no restrictions on the time periods involved. The several hundred abstracts (or bibliographic descriptions) obtained from these searches were carefully reviewed for pertinence to the use of NBC masks with optical accessories. On the basis of this review, the most probably relevant documents were ordered from the searching services. These documents, which are listed in Appendix A, were received over a 2-month period.

The documents obtained from the literature search were studied, and critical information relating to mask-optical accessory compatibility was recorded in a set of notes. From each report, information was extracted and the relevant report number and page were noted. This information is presented for selected documents in Appendix B.

Additional information describing the details of optical equipment was supplied to us by CRDEC. This information can be traced to the following sources:

- Center for Night Vision and Electro-Optics (CNVEO) - Communications, Electronics Command (CECOM)
- Houff, Charles W., "A Preliminary Study of a Protective Mask Lens Design to Reduce Occlusion of Visual Field in Optical Fire Control Instruments," CRDL Technical Memorandum 2-37. December 1965.
- Barnes, et al, "Human Factors Development Test of the XM30 Protective Mask Series," U.S. Army HEL TM4-83. 1983.

Selection of Information. Consolidation of the information obtained from the sources provided a list of optical equipment (Table C-1, Appendix C). This list included equipment that may be obsolete because one of the sources was dated 1965.

Communication Equipment

Sources of Information. The following sources were used to identify models of applicable communication equipment:

- *Federal Supply Class Index*
- Information Handling Service (IHS) Military Specifications CD-ROM Search
- *Jane's Military Communications*
- *Signal Data References; Communications-Electronics Equipment*, Training Circular (TC) 24-24.

The details for interface information were obtained from the following sources:

- Military specifications for radios identified by IHS CD-ROM search
- Vendors of equipment identified from *Jane's Military Communications*
- Ohio National Guard personnel experienced in servicing communication equipment
- U.S. Army Reserve personnel experienced in servicing communication equipment.

Interface information was obtained only for equipment having existing military specifications or for equipment manufactured by vendors currently in business.

Selection of Information. Reviewing published sources produced a list of 166 communication devices and systems (Table E-1, Appendix E). This list included systems that were obsolete, production discontinued, currently used, next-generation, and military adapted commercial radios. The list was condensed to 57 models (Table E-2, Appendix E) that are now in use or that will be placed in use in the near future. However, the TC 24-24 manual used in preparing this list was dated 1987, with a revision due at the end of 1992. Thus the final list may indeed include items that are now—or that soon will be—obsolete.

Other Equipment

Table D-1 (Appendix D) lists additional current and future equipment that may interface with RESPO 21; however, due to time limitations, no detailed information was obtained for the listed devices. Included in Appendix D are photographs and sketches of some of this equipment.

Optical Equipment

Categories of Optical Equipment

In a warfare environment, instruments designed for vision enhancement are of critical importance. These optical devices are used for surveillance, target detection and engagement, and night vision. They are employed as individual-served equipment or as mounted systems on vehicles such as the M1 and M60 tanks and the M2 infantry fighting vehicle as well as on aircraft such as the Apache and Comanche attack helicopters. The categories of applicable optical devices that need to be evaluated for compatibility include the following equipment:

- Aiming circles
- Binoculars
- Image intensifiers
- Periscopes
- Range finders
- Sights
- Telescopes
- Thermal imaging systems
- Laser devices.

Compatibility Considerations

In general, compatibility is the physical match-up of two or more items with respect to the operation and functioning of the items. However, with respect to using optical equipment with NBC masks, the term "compatibility" needs to be better defined. When compatibility is used in reference to computers, it is a dichotomous reference; e.g., if one knows a computer to be IBM-compatible, one can usually assume that IBM software will function properly with the computer. Such an assumption cannot be made with respect to compatibility in this study because it neglects serious performance degradation resulting from using combinations of devices. For example, binoculars might function while a person is wearing an NBC mask, but the combination of mask and binoculars might seriously limit how well the person wearing the mask can see in comparison with how well the person could see unmasked. Therefore, the goal of assessing the compatibility of one device used with another is to identify the aspects of performance that are degraded by the combination and then to evaluate the amount of performance loss with respect to the unmasked condition.

In specifying the design envelope for a RESPO 21 protective system, two aspects of compatibility were evaluated, namely optical performance and physical interfacing. Optical performance, in terms of the apparent field of view (FOV) provided by the optical system, was chosen as a critical criteria because limitations on the vision of the soldier must be minimized. The physical interfacing was also important because the mask should interfere minimally with a soldier's clothing and equipment and vice versa.

Optical Performance Compatibility. For optical systems, the field of view (FOV) is an important performance parameter. The *instrument* FOV is the angular diameter of a cone-shaped zone within which object-points must lie for the optical instrument to form an image. The *apparent* FOV as seen by the viewer through the instrument depends on the location of the human eye relative to the eyepiece lens. Figures 1a and 1b display the parameters needed for calculating the apparent FOV in degrees.

Figure 1a shows the unmasked eye, the parallel light rays A, B, C and D, E, F passing through the eyepiece lens and forming an image of the instrument's aperture stop. This image is called the exit pupil (EP). The intersection of the exit pupil plane with the optical axis is the eye point (I) of the instrument; the distance from the eyepiece lens to the eye point defines the eye relief (ER) of the optical device. The apparent FOV as seen by an unmasked viewer (if his nodal point of eye (NI) is coincident with the instrument eye point) is defined by the angle 2β (BIE) and is calculated by the following equation:

$$\text{Apparent FOV} = 2\beta = \text{magnification x instrument's FOV, degrees} \quad (1)$$

This apparent FOV is the maximum vision field provided by the instrument.

Figure 1b shows the displaced eye when a protective mask is worn. The apparent FOV 2β is smaller than the unmasked FOV. The occlusion is due to the displaced position of the eye relative to the eye relief position. The occluded FOV can be calculated by the following equation:

$$\text{Occluded FOV} = 2\beta^* = 2\tan^{-1}[(0.5(EP+P)-k)/(SOD-ER+PD)], \text{ degrees} \quad (2)$$

with the assumption that:

k = constant vertical pupil aperture of 1 mm (0.039 inch)
P = constant pupil size of 3 mm (0.117)
PD = pupil depth of 3 mm (0.117)

This equation is a modification of the Slogoff equation in which (ER-PD) was substituted for the clear eye distance (CED). Note that the variables in equation (2) are the eye relief, the exit pupil diameter, and the standoff distance (SOD) between the forward face of the mask lens and the cornea of the

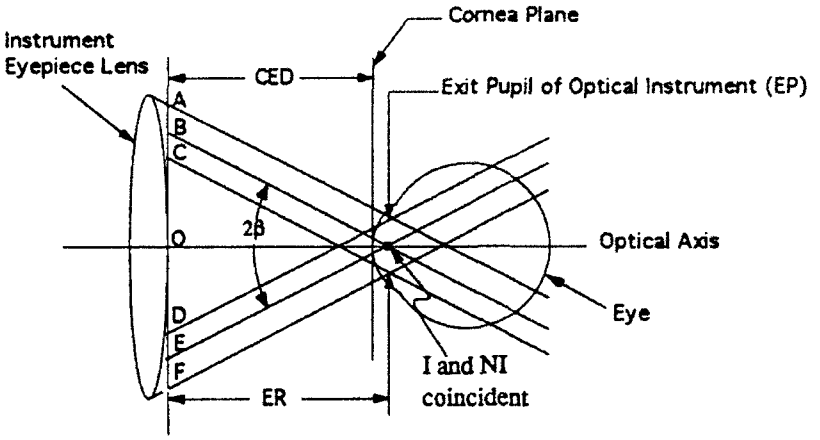


Figure 1a. Cross section of instrument exit pupil with nodal point of eye at instrument eye point.

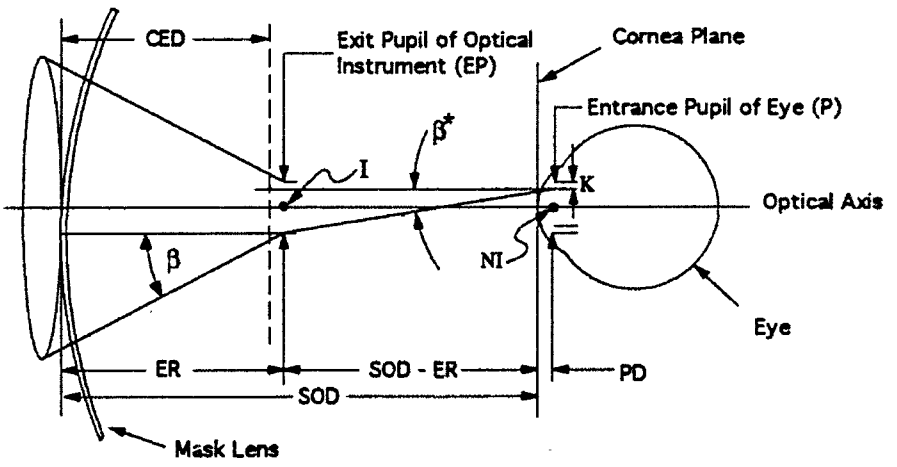


Figure 1b. Cross section of instrument lens, exit pupil and eye with eye displaced when a protective mask is worn.

CED - Clear Eye Distance: From vertex of instrument lens (O) to the cornea of the eye, when the nodal point of the eye is at the eye point (I).
EP - Exit Pupil: Diameter of the field formed by the image of the instrument's aperture stop, as seen in image space on the optical axis of the instrument.
ER - Eye Relief: Distance from the vertex of the instrument lens (O) to the eye point (I).
I - Eye Point: Intersection of the exit pupil plane with the optical axis of the instrument.
K - Vertical pupil aperture at edge of field.
NI - Nodal point of eye: Intersection of the entrance pupil plane of eye with the optical axis of the instrument.
O - Lens Vertex: Intersection of the optical axis with the face of the lens.
P - Pupil Diameter.
PD - Pupil Depth: Distance from the cornea to the pupil.
SOD - Stand Off Distance: Distance from the forward face of the mask lens to the cornea of the masked eye.
2β - Apparent field of view of the instrument (2β ~ 8IE).
2β* - Occluded apparent field of view of the instrument.

FIGURES 1a and 1b. Parameters for Calculating the Field of View

masked eye. The ER and EP are parameters of the optical system, thus only the SOD is a design variable for a RESPO 21 mask.

The occlusion can be derived as a percent difference between the two FOVs in the following equation:

$$\text{Occlusion} = \frac{2\beta - 2\beta^*}{2\beta} \times 100 \qquad (3)$$

The results, assuming various SOD, for specific models of the mentioned categories of optical instruments are shown in Table C-1 (Appendix C).

The FOV for two or more devices in combination depends on two variables: the FOV rating of the most restrictive device used alone and the standoff distance of that device. The data in Table 1 illustrate these effects. M19 binoculars have a field of view of 6. The field of view of a mask is substantially higher—at least 24. Ideally, if the lenses of the mask were at the eyes of the wearer, the field of view for the mask and binocular combination would be 6. However, the mask lenses are located some distance away from the eyes, reducing the field of view. Clearly, a goal of any mask design is to reduce the distance between the eye and the mask lens, within the limitations of human physiology, which according to report B105334, is a 1-inch radius lens, required to clear the eyelashes of the 5th to 95th percentile of humans. A standoff distance for a typical mask was determined in report B096653 to be 1.5 inches for a person wearing eyeglasses and an NBC mask. (For security reasons, the model number of the mask was not specified in the report.)

Also extracted from the resources supplied to us by CRDEC is the information shown in Table 2. This table lists a comparison of mean sight field-of-views between select military optical devices both with and without designated protective face masks.

Physical Compatibility. Another requirement for compatibility between devices is that the two devices fit together comfortably and securely. Several reports described some of these interference problems, including the following:

- Goggles did not mate properly with gas masks (A134912)
- A strap on the night vision goggles (NVG) crushed the protective ear cup of the mask (A020150)
- Donning a mask broke a goggle seal. (A020150)

TABLE 1. Field of View Values for Selected Equipment

Item	Field of View Values	
	Vertical	Horizontal
Night vision goggles (ANVIS, AN/PVS5, AN/PVS6, AN/PVS7)	40	40
Unmasked human	60	97
Night vision goggles with M40 mask	24	24
Night vision goggles with MCU-2P	20	20
M19 binoculars	6	6
M19 binoculars with unidentified masks	3 to 5	3 to 5
M19 binoculars with eyeglasses	5	5
M19 binoculars with eyeglasses and mask	3	3

TABLE 2. Comparison of Mean Sight Field-of-View

Instrument	Field of View (deg.)		
	Without Mask	XM30 Mask	M17A1 Mask
Engineers Transit	1.42	1.23	0.60
M19 Binoculars	6.75	5.48	3.68
M65 BC Scope	5.37	3.12	1.65
M47 Sight (Dragon)	5.63	4.82	3.60 (#)
M32 Tank Sight	8.00	8.33 (#)	7.07 (+)
M105D Tank Sight	7.58	7.5 (#)	7.57 (+)
M1 Telescope Tank Sight	5.97	5.97 (#)	5.88 (+)
M1 Gunner Sight (10X)	4.65	4.00 (#)	3.67 (+)
M1 Gunner Sight (3X)	12.25	10.52 (#)	10.43 (+)
M1 Commander Sight (10X)	5.57	4.30 (#)	3.30 (+)
M1 Commander Sight (3X)	11.92	10.82 (#)	9.67 (+)
M1 Night Periscope	20.08	20.73 (#)	20.30 (+)
AN/PVS-5 NVG	37.23	32.80	26.82
# - XM34 Mask Data + - M25A1 Mask Data			

Some of the reports evaluated the mask more empirically by evaluating the performance of a soldier while doing a task both masked and unmasked. These tasks included:

- Measuring the time to spot a target using field binoculars (B105334, page 16)
- Completing a night helicopter mission (B105334)
- Using an HDU (helmet display unit) (B105334)
- Live firing using an AH-1S telescopic sight in a realistic scenario with and without NVG (A064203)
- Operating tanks and tank equipment (A020150)
- Wearing M5 and M7 hoods (A020150)
- Using M18 binoculars (A020150) and M19 binoculars (B082927L).

Only some of the reports address issues concerning fit between existing respiratory protection masks and optical equipment. Report A020150 describes various brow pad configurations used in sight devices found on tank-type vehicles. This report also provides an assessment of the Model DH-132 Helmet as a functional component of a protective system by investigating the interface with associated equipment such as brow pads, goggles, and protective mask. Also, Report B133508L illustrates and describes fit concerns between the M-40 and the MCU-2/P CWD masks and night vision goggle systems AN/PVS-5C and AN/PVS-7A. This report, like most of the compatibility studies obtained, fails to identify and document the specific design interfaces.

The results from these tests were difficult to compile and compare because most were entries in questionnaires and thus subjective in nature. Tables of average ratings—accompanied by comments—from soldiers asked to rank various attributes of the various mask/device combinations were often used to evaluate the masks. Examples of using optical devices while wearing respiratory protection apparel are shown in Appendix F.

The physical compatibility of a night vision system AN/PVS-5C with RESPO 21 was selected for detailed study. Figures describing the AN/PVS-5C night vision goggle are shown in Appendix G. Figure G-1 shows a front view of the goggles. The user interface (back view) of the AN/PVS-5C NVG is shown in Figure G-2. Figures G-3 and G-4 show a top view of the AN/PVS-5C NVG, indicating the curvature of the user interface, both with and without the face pad. The radius of curvature of the AN/PVS-5C NVG face pad shown in Figure G-5 has been measured as approximately 3.3 inches. Definition of the face pad shape and curvature, along with information on percent occlusion as a function of SOD, should provide face mask designers with adequate information to address compatibility requirements.

Conclusions

The compatibility of RESPO 21 with existing and future optical equipment was evaluated based on optical performance and physical interfacing. The apparent field of view (FOV) was determined to be the optical performance parameter of importance. Physical interference of the mask with a soldier's clothing and equipment was also a concern in specifying the design envelope.

Relating to the optical performance compatibility, the occlusion of the FOV can be reduced by minimizing the displacement of the masked eye from the eye relief position. This can be accomplished in two ways. First, the eye relief can be increased. Designers of future image intensifiers are attempting to lengthen the eye relief from 15 mm to 25 mm. Second, the standoff distance (SOD) can be reduced. The design envelope for a RESPO 21 mask should specify a SOD that minimizes the occlusion for a majority of the optical systems while maintaining adequate distance for comfort and for other mask functions. The optional equipment listed in Table C-1 (Appendix C) identifies percent occlusion for set values of SOD, which should provide guidance for establishing a general design envelope.

It is important to note that future compatibility requirements may be highly affected by two trends in optical equipment development. First, there is an interest in switching from direct sighting systems to displays: either helmet mounted displays or panel displays. However, direct sighting systems will remain in inventory. Second, the development of integrated helmet systems will present the biggest challenge to RESPO 21 compatibility issues. Thus, both trends may affect the design envelope of RESPO 21.

The literature surveyed in this task did not provide sufficient details for establishing a specific design envelope for defining and developing RESPO 21 concepts. In addition to the available data compiled on optical systems, this report can present only analyses of historical information—mostly subjective views—from various sources on protective mask-optical equipment interface problems. These analyses can only suggest some of the critical areas respecting compatibility of optical systems with RESPO 21.

Moreover, the procedures described in the literature for evaluating compatibility suggest that compatibility cannot be accurately determined by means of a "paper" study. That is, comparing measurements and capabilities of a mask with physiological and equipment measurements and capabilities require applying experiential techniques. The normal technique for determining compatibility is to use a population with required/desired percentile characteristics and to have this population wear the subject mask while operating various optical devices under controlled conditions.

In order to provide engineers and designers involved in developing RESPO 21 with accurate, representative, anthropometrically based data, experimentally determined test data will have to be generated specifically for the purpose. Therefore, specific items of equipment will have to be identified and selected, and their compatibilities with RESPO 21 design concepts will have to be determined. Indeed, the items themselves should be available for measuring, investigating, and testing. Furthermore, this testing will require a basic understanding of the anthropometric variations in the population likely to wear RESPO 21. Testing will include documenting the performance (or results of use) of subject equipment when operated by test subjects, both when wearing and when not wearing a representative protective mask. Other test conditions and parameters will have to be selected, designed, and developed after thoughtful consideration of mask, optical device, and RESPO 21 fielding requirements. Only such carefully considered and crafted testing can provide the designer with the quantitative guidelines needed for developing RESPO 21 design concepts compatible with present and future battlefield equipment.

Communication Equipment

Categories of Communication Equipment

Numerous communication devices are used in ground warfare environments, both in the front and rear areas. Because the communication capability of RESPO 21 will be limited to speech in the field and in military vehicles, the categories of applicable communication devices include the following equipment:

- Single-channel radio equipment
- Multichannel radio equipment
- Line systems radio equipment.

Equipment Selected for Evaluation

RESPO 21 will interface with equipment now in the field or that is planned to be fielded. Therefore, an effort was made to identify specific radio equipment that is obsolete or for which production has been discontinued. For the purpose of this study, obsolescence means that a radio has been replaced with a newer model and has been removed from inventory. Personnel from the Ohio National Guard in Newark, Ohio, identified five radios known for sure to be obsolete. Vendors of

military communication equipment identified eight radios on our master list as being no longer in production.

Pertinent Characteristics of Selected Equipment. To specify the design envelope for RESPO 21, it was necessary to determine the types of interfaces needed between a RESPO 21 communication device and military radios. Consultation with Battelle staff knowledgeable in electronics and communication devices and with vendors of radio equipment revealed the following three types of interface:

- Audio accessories
- Mechanical interface between audio accessory and radio
- Electrical interface between audio accessory and radio.

Audio accessories include handsets, headsets (with and without an associated microphone), and hand-held microphones. These accessories interface mechanically with the communication equipment via connectors that have different pin configurations and wiring. Depending on the model of accessory and communication equipment, the electrical interfaces may also be different. These electrical interfaces include the frequency response range for speech communication, the input and output voltages and power levels, and the matching terminal impedances.

Compatibility Considerations. Several steps were taken in specifying the design envelope for a RESPO 21 communication system from both electrical and configuration perspectives. First, the types and specific models of communication devices with which RESPO 21 would interface were identified. Second, details were obtained on the mechanical and electrical interfaces between the communication systems and the audio accessories. Third, the design envelope was specified based on a representative audio accessory that mechanically and electrically interfaces with many currently used communication devices.

Mask-Equipment Interface

Identifying the mechanical interface, namely the connectors, between the audio accessories and their associated radios revealed that only two categories of radios were significant. One category of radio uses a 10-pin plug connector (U-161/U, with its mating receptacle U-77/U). These 10-pin radios are the older AM single-channel (SC), single-side band (SSB) equipment. The other category of radios uses a 6-pin plug connector (U-182/U or U-229/U, with a mating receptacle U-183/U). The 6-pin radios operate in both AM and FM single-channel, single-side band modes as well as in FM

multichannel mode. The pin configurations and wiring are shown in Figure E-1 (Appendix E). The first seven pins of the 10-pin connector and the first four pins of the 6-pin connector are used for audio signals. Thus the mechanical interfaces are standard for the two categories of radios.

The electrical interface between audio accessories and the associated radios was also found to be standard. The speech frequency response for the microphones and earphones in both categories of radios range from 300 hertz to 3500 hertz. The nominal microphone input impedances for the 10-pin radios are 40 ohms and for the 6-pin radios are 150 ohms. The typical earphone output impedances for the 10-pin radios are 300 ohms and for the 6-pin radios are 300, 600, or 1000 ohms.

Although the frequency range and the terminal impedances are uniform for the two categories of radios, the individual characteristics of each radio result in variations in the performance of the microphones and earphones. Depending on the input and output voltages and power levels of each radio, the frequency response profile varies between radios. However the differences may have negligible effects on speech intelligibility. Because the differences in intelligibility between the categories of radios may be negligible, representative handsets such as the H-33/PT for the 10-pin radios and the H-250/U for the 6-pin radios can be used to specify the design envelope for a RESPO 21 communication device.

Table E-1 (Appendix E) lists the audio accessories that comply with the 10-pin and 6-pin electrical interface requirements. Table E-2 (Appendix E) lists the detailed electrical interface information for each handset and radio chosen as representative equipment. It may be significant that the 10-pin radios use a carbon microphone that requires a voltage supply to operate while the 6-pin radios have a dynamic microphone that is passive or needs no power supply. Thus additional circuitry may be required to adapt the RESPO 21 communication device to both types of radios.

Radios used as line systems in shelters or tanks that require both intercom and radio communication were generally found to have audio accessories incorporating a Y-junction adapter terminating in two connectors. Thus a RESPO 21 communication device could incorporate a similar adapter cable assembly to accommodate both types of communication.

Conclusions

The task of determining the compatibility of a RESPO 21 communication device with a large number of radios has resulted in a simple design envelope focussing on 6-pin radios. The 10-pin radios of the AM SSB type, such as the AN/GRC-106, are still used but may be phased out by 1994. Thus, these radios were removed from consideration (also because of the incompatibility between active and passive microphones).

The 6-pin radios and their associated audio accessories comply with the military specifications for audio performance. Consequently, the microphone and earphone frequency responses of one radio are similar to those of other radios. A family of radios such as SINCGARS and a handset such as the H-250/U represent the mechanical and electrical interface constraints for the design envelope of a RESPO 21 communication device. The electrical characteristics of these items are listed in Table 3.

TABLE 3. Electrical Characteristics of the H-250/U Handset and the SINCGARS Radios

Model	Pin	Signal Name	Signal Characteristics	Input Impedance	Output Impedance
H-189/GR H-250/U (HANDSETS)	A	Ground			
	B	Audio RCVR	Response: 20-3500Hz, 104-110dB at 0.0002 dyne/cm2 with 1mW		1000 ohms
	C	Push-To-Talk	Grounding this line keys transmitter in the RT unit		
	D	Audio XMT	Response: -56 dBm (0.613mVrms) min with 1kHz input of 28 dynes/cm2	150 ohms	
	E	NA			
	F	NA			
AN/PRC-119 AN/VRC-87, 88, 89, 90, 91, 92 (SINCGARS)	A	Ground			
	B	Audio RCVR	Response: 300-3000Hz, +2/-3dB @1kHz ref; Power: 50mW		600 ohms
	C	Push-To-Talk	XMT = OV +/-0.5V, RCV = open, pin held at 1.2VDC internally		
	D	Audio XMT	Input Levels: 300-3000Hz, -48.8dBm (1.4mVrms) / -3.8dBm (250mVrms)	150 ohms	
	E	Fill Info	Digital Clock 1=-6.75V, -0.5V/+1V; 0+0V+/-0.5V		
	F	NA			

CONCLUSIONS AND RECOMMENDATIONS

It was frequently difficult, and sometimes impossible, to obtain the necessary interface details from the resources contacted. This difficulty arose from the extreme generality of the listing of equipment that supposedly will or might be used with RESPO 21. Under these circumstances, identifying the necessary details of a single piece of equipment requires an inordinate amount of time. It is recommended that—in order to focus the investigation for future efforts—specific equipment be identified for compatibility assessment.

Also, more information is required on specific details of RESPO 21 itself: information dealing with design concepts, preliminary layouts, anticipated characteristics, and implementation schedules. This information would provide valuable—and needed—insight, both to obtaining information on equipment for use with RESPO 21 and to applying the information so obtained.

Based on the findings of this program, it is evident that detailed information on select equipment simply does not exist in a form that is useful to designers and engineers. Therefore, it is recommended that tests be conducted that are specifically aimed at investigating and documenting the details associated with the critical interfaces. It is also recommended that anthropometric variations over the end user population be factored into the interface details.

APPENDIX A

Listing of Documents Obtained from Literature Search on Mask Technology

FIGURE A-1. Documents from Literature Search on Mask Technology

	AD NUMBER	CBIAC	REC'D	PAGES	TITLE
O	A020150		8/28/92	NA	A HUMAN FACTORS ENGINEERING COMPATIBILITY ASSESSMENT OF THE DH-132 HELMET, COMBAT VEHICLE CREWMAN (CVC)
O	A041 249		8/25/92	61	VISUAL & OPTICAL ANALYSIS OF XM-29 & M-24 PROTECTIVE MASKS
O	A064 203		8/28/92	35	AN INTERFACE EVALUATION OF THE XM-29 PROTECTIVE MASK & THE AH-1S TELESCOPIC SIGHT UNIT
O	A091737		8/25/92	NA	MASKS, PROTECTIVE
O	A134912		8/28/92	12	THE OBJECTIVE EVALUATION OF AIRCREW PROTECTIVE BREATHING EQUIPMENT V. MASK/GOGGLES COMBINATIONS FOR FEMALE CREWMEMBERS
O	A143535		8/28/92	32	EFFECTS OF CHEMICAL PROTECTIVE & OXYGEN MASKS ON ATTENUATION & INTELLIGIBILITY WHEN WORN WITH THE SPH-4 HELMET
O	A188478	CB-000875	8/25/92	174	THE EFFECTS OF US ARMY CHEMICAL PROTECTIVE CLOTHING ON SPEECH INTELLIGIBILITY, VISUAL FIELD, BODY MOBILITY & PSYCHOMOTOR COORDINATION OF MAN
O	A215173		8/28/92	38	ANTHROPOMETRY OF A FIT TEST SAMPLE USED IN EVALUATING THE CURRENT & IMPROVED MCU-2/P MASKS
O	A230237		8/28/92	NA	A FIELD EVALUATION OF THE COMPATIBILITY OF THE PROTECTIVE INTEGRATED HOOD MASK WITH ANVIS NIGHT VISION GOGGLES
O	B082927L		8/20/92	NA	BINOCULAR SCANNING PERFORMANCE FOR SOLDIERS WEARING PROTECTIVE MASKS
O	B086696L		8/20/92	27	DEVELOPMENT TEST IIA OF NIGHT VISION GOGGLES (NVG) AS/PVS7
O	B096653	CB-004699	8/20/92	23	BINOCULAR SCANNING PERFORMANCE FOR SOLDIERS WEARING PROTECTIVE MASKS II
O	B101723		7/21/92	46	CUSTOMER TEST OF THE XM-43 PROTECTIVE MASK COCKPIT COMPATIBILITY
O	B105 334		7/21/92	24	CUSTOMER TEST OF THE XM-43 AIRCREW PROTECTIVE MASK COCKPIT COMPATIBILITY
O	B127111		7/21/92	NA	FOLLOW-ON EVALUATION OF NIGHT VISION GOGGLE AN/PVS-7A. PRETEST INVENTORY & INSPECTION, SAFETY, HUMAN FACTORS ENGINEERING, LOGISTIC SUPPORTABILITY, & ELECTROMAGNETIC PULSE SUBTESTS
O	B133508		7/21/92	19	COMPATIBILITY OF NIGHT VISION GOGGLES & CHEMICAL WARFARE MASKS
O	B161143		7/21/92	80	HEL EVALUATION OF VISION-CORRECTIVE INSERTS FOR THE M40 PROTECTIVE MASK
	150346			NA	FACE SIZE PROJECT
	465030	CB-000391		127	INDIVIDUAL RESPIRATORY PROTECTION AGAINST CHEMICAL/BIOLOGICAL AGENTS
*	384034L			NA	NIGHT VISION GOGGLES
	439822L			NA	DEVELOPMENT OF EYE, HEAD OR FACE PROTECTIVE DEVICES
*	913067L			NA	STUDIES ON PERFORMANCE FACTORS IN PROTECTIVE MASK DESIGN
*	A091737			91	MASKS, PROTECTIVE
	A162033			NA	AUTOMATED CHEMICAL WARFARE RESPIRATOR QUANTITATIVE FIT TEST INSTRUMENT
	A163102			38	STATISTICAL ASSESSMENT OF THE XM40 MASKS & US-10 RESPIRATOR
	A192430			375	SIZING DETERMINATION FINAL REPORT
	A218172			NA	A NEW FACILITY DESIGN & WORK METHOD FOR THE QUANTITATIVE FIT TESTING
	B000799L			NA	HUMAN FACTORS EVALUATION OF TWO PROPOSED ARMY INFANTRY/MARINE FRAGMENTATION PROTECTIVE SYSTEMS
	B002025L			NA	CHECK TEST OF MODEL P/N 791 HELMET
	B015337L			NA	STUDIES TO ESTABLISH QUANTITATIVE PARAMETERS FOR THE DESIGN OF LARGE & SMALL SIZES OF THE NEW PROTECTIVE MASK
	B023709			75	DT I TECOM INDEPENDENT EVALUATION REPORT FOR THE NEW PROTECTIVE MASK, XM29
	B064175L			NA	MODIFICATION OF FIELD PROTECTIVE MASK
*	B066316			70	INITIAL OPERATIONAL TEST & EVALUATION. SECOND GENERATION EYE/RESPIRATORY PROTECTIVE SYSTEMS
	B069594L			33	CUSTOMER TEST OF MINIMUM CHANGE/MINIMUM RISK PROTECTIVE MASK RCS ATTE-E
	B069778L			NA	CUSTOMER TEST OF MINIMUM CHANGE/MINIMUM RISK PROTECTIVE MASK
	B069876L			74	CUSTOMER TEST EVALUATION OF THE MINIMUM CHANGE/MINIMUM RISK MASK DESIGN CONCEPT
	B070274			122	DEV. TEST II (PQT-G) OF XM33 PROTECTIVE MASK, HOOD, & COMBAT SPECS
*	B072814	CB-005778		73 DUP	EVALUATION OF COMBAT VEHICLE GUNNER PERFORMANCE WITH VARIOUS COMBINATIONS OF NBC PROTECTIVE APPAREL: A LABORATORY STUDY
	L074031			27	CUSTOMER TEST OF THE XM-40 PROTECTIVE MASK
	B076595L			41	CUSTOMER TEST OF XM40 PROTECTIVE MASK & FOREIGN MASK
	B081538L			63	OPERATIONAL TEST 2A OF FACE MASK, COMBAT VEHICLE CREWMAN'S CLOTHING SYSTEM
*	B087050			109	DETAILED TEST PLAN DEVELOPMENT TEST II PROTOTYPE QUALIFICATION TEST-GOVERNMENT (PQT-G) OF XM41 & US-11 PROTECTIVE MASKS HOOD & COMBAT
*	B093 959			34	RUSSIAN RIFLE/PROTECTION MASK EVALUATION
	B096187L			31	CUSTOMER TEST OF XM40 MASK & BRITISH S-10 RESPIRATOR
	B097014			200	OPERATIONAL TEST II OF THE XM-41 CHEM, BIOLOGICAL PROTECTIVE MASK & US-11
	B097023			35	EVALUATION OF SEVERAL CHEMICAL PROTECTIVE CLOTHING ENSEMBLES FOR NAVAL USE

'O' Indicates a report was ordered. '*' Indicates a report was initially considered but not ordered.

FIGURE A-1. Documents from Literature Search on Mask Technology (Continued)

	AD NUMBER	CBIAC	REC'D	PAGES	TITLE
	B100670	CB-004522		74	ANALYSIS OF CHEMICAL & BIOLOGICAL PROTECTIVE MASK DATA (RAM &HF)
	B102970L			NA	DEVELOPMENT TEST II (PROTOTYPE QUALIFICATION TEST-GOVERNMENT) (TROPIC ENVIROMENTAL PHASE) OF XM40 PROTECTIVE MASK, PROTECTIVE HOOD, & CORRECTIVE SPECTACLES, & US-10 RESPIRATOR
	B103285			191	INDEPENDENT EVALUATION REPORT OF THE XM40 CB PROTECTIVE MASK & US-10 RESPIRATOR
	B106934			74	FOOD/DRINK/SPEECH SYSTEMS FOR RESPIRATORY PROTECTION
	B109799L			117	INDIVIDUAL PROTECTION TESTING. TASK 1 PROTECTIVE ENSEMBLE TESTING
	B111291	CB-000923		40	INDEPENDENT EVALUATION REPORT, AH-64 AIRCREW PROTECTIVE MASK
	B112780	CB-000769		166	XM40 MASK PREPLANNED PRODUCT IMPROVED FINAL REPORT
	B112780L			169	XM40 MASK PREPLANNED PRODUCT IMPROVEMENT
	B113420L			NA	EVALUATION OF SIZING TECHNIQUES FOR THE XM40 PROTECTIVE MASKS
	B116057	CB-000164		40	STATISTICAL ANALYSIS OF PROTECTION FACTOR DATA PROVIDED BY XM40 MASK/HOOD PROTOTYPE CONCEPT TESTING
	B118268	CB-001575		18	INDEPENDENT EVALUATION REPORT OF THE XM-43 AIRCREW PROTECTIVE MASK
	B122879			182	ENGINEERING DEVELOPMENT OF NEW PROTECTIVE MASK, XM40
	B122879L			NA	ENGINEERING DEVELOPMENT OF NEW PROTECTIVE MASK, XM40 PHASE 2 FABRICATION
	B123676			111	CUSTOM SIZE M40 PROTECTIVE MASK
*	B124349	CB-010638		545	DEVELOPMENT TEST II (PQT-G) OF XM40 SERIES PROTECTIVE MASKS, HOODS, & ACCESSORIES
	B125967L			47	PROTECTION MAXIMIZATION PHASES 1 & 2
	B127758L			112	XM40/US-10 FOLLOW-ON TEST & EVALUATION
	B136190			89	AIRCREW EYE/RESPIRATORY PROTECTION SYSTEM, INITIAL OPERATIONAL TEST & EVALUATION
	B139162			82	PRODUCTION PROVEOUT TEST ON THE M43 CHEMICAL-BIOLOGICAL PROTECTIVE MASK FOR THE AH-64 HELICOPTER (OPTICAL CORRECTION REEVALUATION) REVISION
	B142132			57	FIELD EVALUATION OF MCU-2/P MASK PROTECTION
	B143365	CB-007685		68	SUMMARY REPORT OF THE CRDEC IPE TECHNOLOGY WORKSHOP
	B151758L			NA	CONCEPTUAL DEVELOPMENT OF A HELMET INTEGRATED INFRARED IMAGING SYSTEM FOR FIREFIGHTERS
	B160118L			64	(NBC) SURVIVABILITY TEST IN SUPPORT OF ENGINEER DESIGN TEST OF THE M40 PROTECTIVE MASK, PREPLANNED PRODUCT IMPROVEMENT PROGRAM
	B160220			28	ABBREVIATED TEST REPORT FOR THE IPT OF THE M40 PROTECTIVE MASK
	B161477			26	M42 PROTECTIVE MASK WEAR & CARRY TEST
	C039400			75	CONCEPT EVALUATION OF LIGHTWEIGHT NBC EQUIPMENT IN SOF
	C040192L			NA	INDEPENDENT EVALUATION FOR PRODUCT IMPROVEMENT PROGRAM OF THE M17 SERIES PROTECTIVE MASK HEADHARNESS, SUPPLEMENT2
*	C044459L			60	INITIAL PRODUCTION TEST, CHEMICAL-BIOLOGICAL PHASE OF AN/PVS-7A NIGHT VISION GOGGLE
	C044948L			NA	M17 MASK FOLLOW-ON EVALUATION
*	D750169			NA	FIT FACTORS OF AN ANTHROPOMETRICALLY DESIGNED THREE SIZE HALF MASK
	D750433			NA	EVALUATION OF QUANTITATIVE FIT FACTOR (QF) OF SWEDISH PROTECTIVE MASK
*	D751205	CB-012525		3	CONCEPTION STUDY OF THE NEW MILITARY FRENCH NBC MASK
*	D751209	CB-012529		9	AN APPROACH TO THE DEVELOPMENT OF THE CAD/CAM EXPERT SYSTEM USED FOR DESIGNING & MAKING MODELS FOR GAS MASKS
	DF316425			?	MASK FIT FIELD STUDY - PHASE I
	DF388884			?	DEVELOPMENT & TESTING OF THEORETICAL SIZING SYSTEMS
*	DF388885			?	APPLICATION OF ANTHROPOMETRIC DATA TO BODY FORMS
				NA	MASK FIT FIELD STUDY - PHASE I
				NA	STUDIES ON PERFORMANCE FACTORS IN PROTECTIVE MASK DESIGN
				NA	INDIVIDUAL RESPIRATORY PROTECTIVE EQUIPMENT- FEASIBILITY STUDIES
		CB-016551		16	FRONT END ANALYSIS FOR RESPIRATORY PROTECTION EQUIPMENT, AN OVERVIEW
		CB-015469		19	NEW PROTECTIVE MASK JOINT SERVICE OPERATIONAL REQUIREMENT APPROVED
		CB-015575		1	THREE DIMENSIONAL ANTHROPOMETRY TO IMPROVE NBC RESPIRATOR DESIGN

"O" Indicates a report was ordered. "*" Indicates a report was initially considered but not ordered.

APPENDIX B

Summaries of Selected Reports on Mask-Optical Equipment Compatibility

APPENDIX B

Summaries of Selected Reports on Mask-Optical Equipment Compatibility

I. Report B105334 (same as B101723L) - *Compatibility Assessment of Cockpit with the XM43 Mask in OH-58C and UH60A Helicopters*

A. Found that a lens radius of 1 inch is adequate for eyelashes to clear for people in the 5th to 95th percentile. (page 2)

B. Determined that the XM43 was compatible with the HDU (helmet display unit).

C. Tests concluded XM43 is compatible with field binoculars. The test involved measuring the time required for the subject with and without the mask to spot a target. (page 16)

D. Tests done on ANVIS 6 and AN/PVS-5 NVG.

1. One in ten subjects had to abort a night mission test due to lens fogging.
2. Some subjects using the XM43 and AN/PVS-5 had difficulty navigating because the limited space between NVG's and the nose cup/lower lens area of the mask made map reading difficult. (page 12)
3. No complaints from pilots when they wore the XM43 with the SPH-4 flyers helmet. (pg. 15)

II. Report A064203 - *An Interface Evaluation of the XM-29 Protective Mask and the AH-1S Telescopic Sight Unit*

A. To create a realistic scenario, tests involved live firing while wearing the mask, both with and without the NVG's.

B. All comments were favorable on the XM-29 mask with the exception of one subject who had a problem with depth perception. Subjects preferred the XM-29 to the M-24.

C. Some slight difficulties were encountered when reading the FLIGHT ATTITUDE and ENGINE CONDITION lights.

D. Visual perception comments from subjects were collected using a questionnaire. Answers ranged on a scale of 1 to 7, with 1 being "Extremely Good" and 7 being "Extremely Bad." The summary evaluation was as follows:

1. Facepiece clarity: 2
2. Field of view: 1.3
3. Image sharpness: 1.3
4. Depth perception: 2.3
5. Distortion levels: 2.3
6. Unreflectivity of facepiece: 3.3
7. Glare reduction: 2.5.

E. The M-24 has a poor FOV (-3 on a scale of -3 to 3), whereas the XM-29 has a good FOV (+1)

III. Report A020150 - *A Human Factors Engineering Compatibility Assessment of the DH-132 Helmet, Combat Vehicle Crewman (CVC)*

The HEL requested that the Army Development and Engineering Directorate (DED) assess the DH132 Helmet System compatibility and interface with the M25A1 Protective Mask and MS protective hood. The report concludes that the DH-132 does not solve compatibility problems of the T-56 helmet.

A. Equipment used during the tests included tanks and tank equipment, M25A1 protective masks, *M5 and M7 protective hoods, M18 I.R. binoculars, and the SU 50 Electronic-Passive IR* (AN/PVS-5 NVG).

B. The right ear cup has male connectors for receiving the microphone cable of the M25A1 mask.

C. Some notes of interest describing how to fit helmets to heads using anatomical parameters are included. (page 8)

D. The M60 tank has a target designation system and periscope which can be seen through easier without the DH-132.

E. If the NVG strap is outside the mask, it will crush the protective ear cups. Additionally, when installing the mask, caution must be used to avoid breaking the goggle seal. (page 44)

F. Problems with the ear seal were encountered when wearing the helmet and protective mask. (page 54)

G. FOV measurements referred to another report: paragraph 148B, TM 9-258, May 1966. An FOV test was done on the periscope, and the results are shown on page 54.

APPENDIX C

Occlusion of the Field of View for Optical Equipment

TABLE C-1. Occlusion of the Field of View for Optical Equipment

Instrument	Magnification	Field of View(deg)	Exit Pupil Dia. (in)	Eye Relief (in)	% Occlusion		
					SOD=1.36 in	SOD=1.3 in	SOD=0.75 in
AIMING CIRCLES							
* M1 Abrams tank	4	10	0.156	0.543	66	63	0
* M2 Infantry Fighting Vehicle	4	10	0.156	0.800	51	45	0
BINOCULARS							
* M13	6	8.5	0.197	0.184	78	76	54
^ M15	7	7.25	0.280	0.361	68	66	31
* M17	7	7.25	0.280	0.361	64	62	12
IMAGE INTENSIFIERS							
# AN/AVS-6	1	40					
# AN/PVS-2	3.6	10					
# AN/PVS-4	3.8	15					
# AN/TVS-4	7	9					
# AN/PVS-5,5A,B,C	1	40	0.394	0.591	31	27	0
# AN/TVS-5	6.5	9					
# AN/VVS-2(V)		38 H 45 W					
# AN/PVS-7A	1	40					
Eagle Eye NVG	1	40	0.394	0.591	31	27	0
PERISCOPES							
* M15,XM34,XM36	7	10	0.281	0.184	78	77	55
* M20	6	8	0.200	0.792	50	45	0
* XM32,XM35,M29,M31	8	8	0.200	0.630	71	68	0
* M30	1.5	48	0.170	0.819	70	66	0
RANGE FINDERS							
* M12(T43)	7.5	5	0.197	1.000	3	0	0
* M13,M17	10	4	0.120	0.644	68	65	0
* M14	7.5	5	0.197	0.883	26	16	0
* M15	8.6	4.05	0.174	0.833	34	26	0
SIGHTS							
* M28	1.5	48	0.170	0.819	70	66	0
* M39	1.8	22	0.200	0.825	36	29	0
^ M1 G.P.S. day	10	6.5	0.236	0.866	61	57	0
^ M1 G.P.S. day,wide FOV	3	16	0.236	0.866	47	42	0
^ M1 G.P.S. night	10	5	0.236	0.866	49	44	0
^ M1 G.P.S. night, wide FOV	3	16	0.236	0.866	47	42	0
^ M1 G.A.S.	8	8	0.236	0.866	60	56	0
^ M2 Hughes Integrated Site	2	15	0.250	1.250	0	0	0
^ M2 day	13	5	0.250	1.250	0	0	0
^ M2 night (low mag)	2	6.6	0.285	1.250	0	0	0
^ M2 night	13	2.2	0.285	1.250	0	0	0
^ M60A1 G.P.S. day		8	0.197	0.629			
^ M60A1 G.P.S. night		7.3	0.590	0.590			
^ M60A1 G.P.S.	8	7.5	0.197	0.940	59	54	0
^ M60A3 G.P.S. day		8	0.197	0.591			
^ M60A3 G.P.S. night		7.3	0.591	0.591			
^ M60A3 G.P.S.	8	7.5	0.197	0.940	59	54	0
TELESCOPES							
* M90	3	13.33	0.300	1.250	0	0	0
* M97	8	7.4	0.198	1.258	0	0	0
* M99	4	10	0.200	1.250	0	0	0
* M100	4	10	0.245	1.030	0	0	0
* M101	4	10	0.240	1.458	0	0	0
* M102	8	7.5	0.196	1.270	0	0	0
* M103	3	10	0.250	0.970	0	0	0
* M104	4.1	15.67	0.347	1.400	0	0	0
* M105	8	7.5	0.197	0.970	44	34	0
* M116	3	13.35	0.300	1.250	0	0	0
* T176	4	10	0.236	2.000	0	0	0
* M65	10	6	0.177	0.600	73	71	0
TELESCOPES-ELBOW							
* M2A1	8	8.75	0.144	0.240	87	86	71
* M16	3	13.03	0.300	1.250	0	[illegible]	0
* M62	3	12.2	0.150	0.600	61	58	0
* XM107	6	7	0.100	0.250	83	82	62
* XM114	8	8	0.276	0.600	63	60	0
TELESCOPES-OBSERVATION							
* M48	19.6	2.13	0.100	0.281	82	81	60
* M49	20	2.2	0.209	0.108	74	73	50

* - Houff (1965), # - CNVEO, ^ - Barnes (1983)

TABLE C-1. Occlusion of the Field of View for Optical Equipment (Continued)

Instrument	Magnification	Field of View(deg)	Exit Pupil Dia. (in)	Eye Relief (in)	% Occlusion		
					SOD=1.36 in	SOD=1.3 in	SOD=0.75 in
TELESCOPES-PANORAMIC							
* M12	4	10	0.165	1.003	20	5	0
* M100	4	10	0.245	1.332	0	0	0
* XM113	4	10	0.226	0.880	23	12	0
* XM115	4	10	0.160	1.100	0	0	0
* T177	4	10	0.165	0.700	56	52	0
THERMAL IMAGING SYSTEMS							
# AN/PAS-7	2.5	6 H					
	2.5	12 W					
# AN/TAS-4A,B,C,D	12	1.13 H					
	12	2.26 W					
	14	3.4 H					
	14	6.8 W					
# AN/TAS-5	4	3.6 H					
	4	6.8 W					
# AN/TAS-6	9	1.13 H					
	9	2.26 W					
	3	3.4 H					
	3	6.8 W					
# AN/VSG-2	1	2.58 H					
	1	5 W					
	8	2.58 H					
	8	5 W					
	2.67	7.74 H					
	2.67	15 W					
	8	7.74 H					
	8	15 W					
LASER DEVICES							
# AN/GVS-5							
MELIOS SYSTEM							
# AN/PVS-6	7	7					

* - Houff (1965), # - CNVEO, ^ - Barnes (1983)

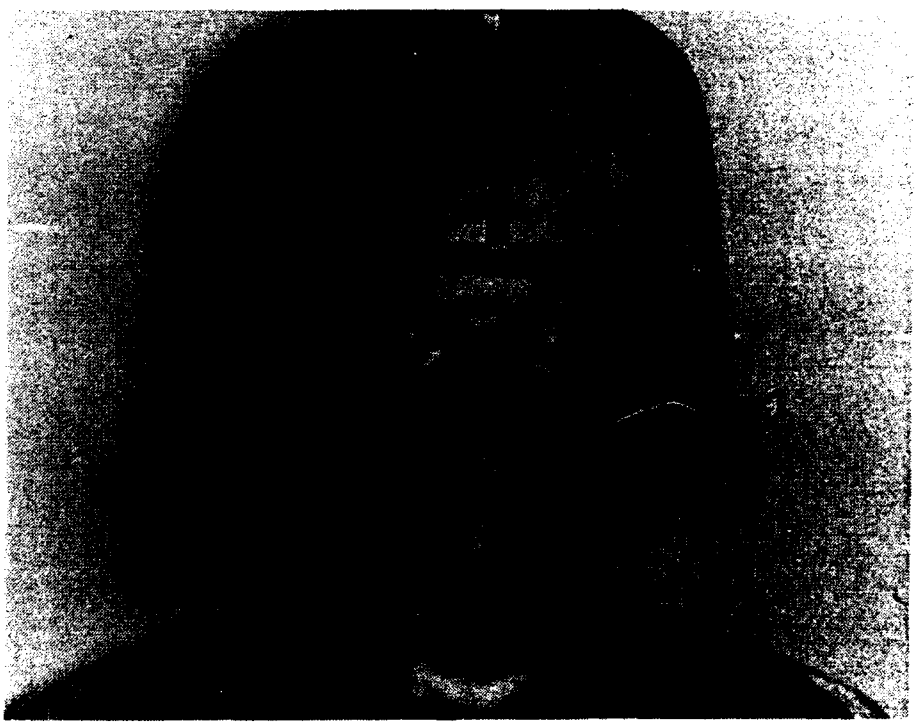
APPENDIX D

Current and Future Equipment
That May Interface With RESPO 21

TABLE D-1. Equipment Requiring Interfacing with RESPO 21

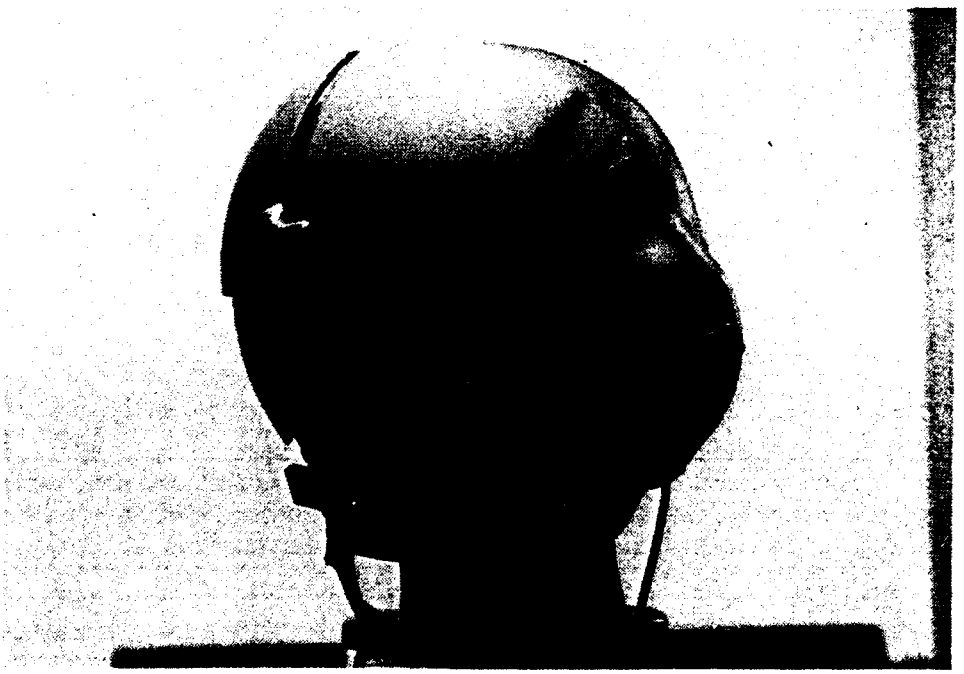
Weapons Fire Control M16A1 Rifle M1911A1 .45-Caliber Pistol M203 Grenade Launcher M60 Machine Gun 25-mm Cannon and 7.62-mm Coaxial Machine Gun .50-Caliber Machine Gun Dragon Missile M72A2 LAW M70 Tow Missile
Clothing and Equipment **Headgear** Apache Helicopter Pilot Helmet Comanche Helicopter Pilot Helmet SPH-4 Helmet DH-132 Combat Vehicle Crew Helmet PASGT Helmet - ground troop SIPE Phase II Integrated Headgear Subsystem with XM-44 Developmental Respirator
Load Carrying Equipment Armor Vest - Integrated Tactical Load Bearing System Individual Equipment Belt Individual Equipment Belt Suspenders Small-arms Ammunition Case Entrenching Tool Carrier Canteen Cover First Aid Dressing/Compass Case Field Packs Uniform Ensemble - cold/wet, cold/dry, desert, wet weather, chemical protective

Apache Helicopter Pilot Helmet

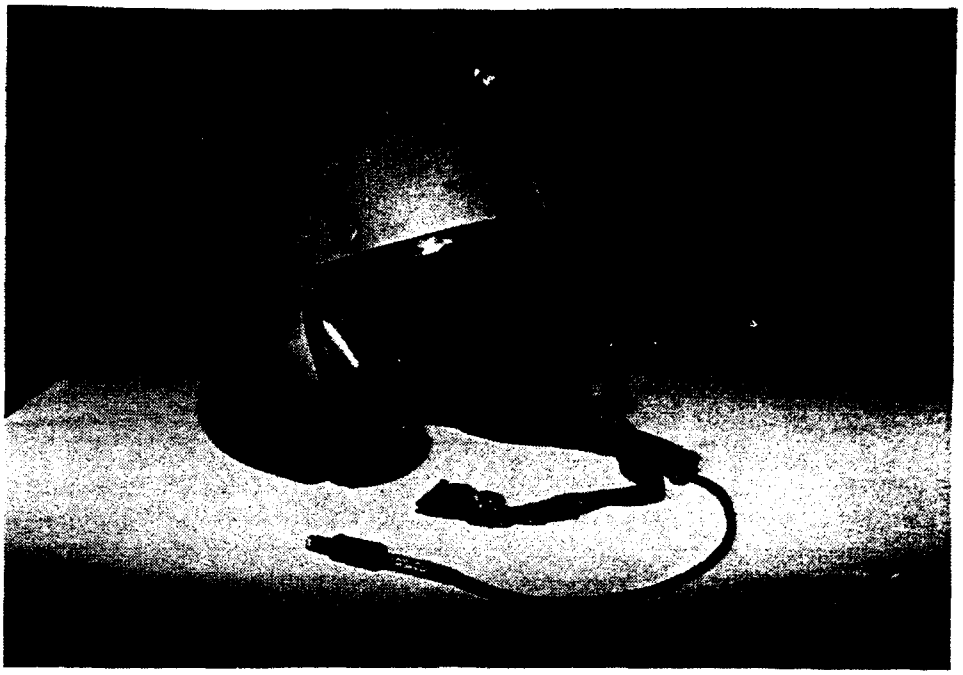


Comanche Helicopter Pilot Helmet

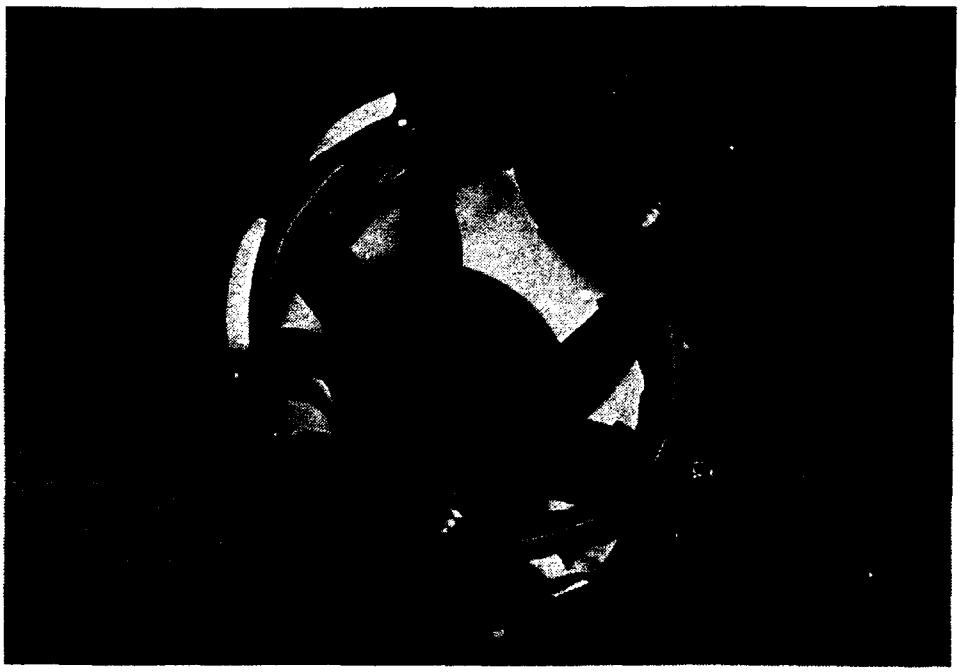
SPH-4 Helmet



SPH-4 Helmet



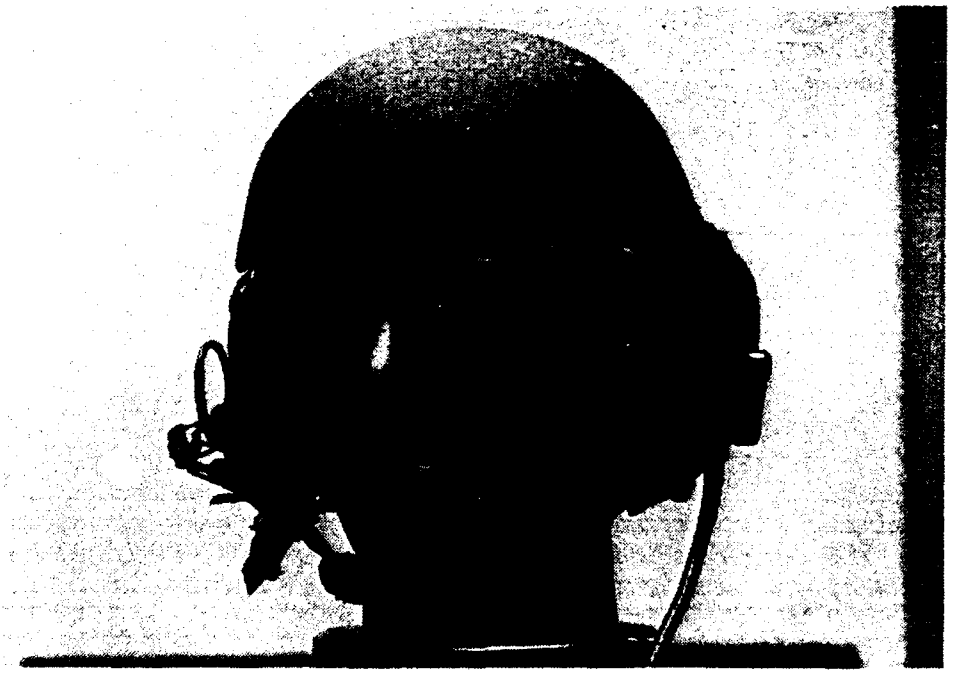
SPH-4 Helmet



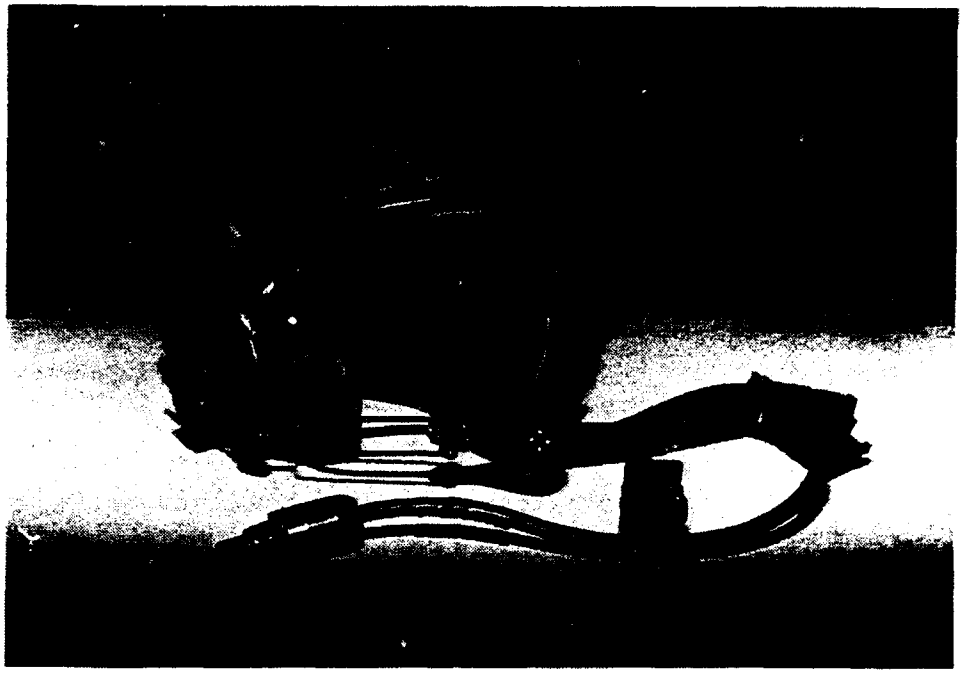
SPH-4 Helmet

SPH-4 Thermal Plastic Liner

DH-132 Combat Vehicle Crew (CVC) Helmet



DH-132 CVC Helmet

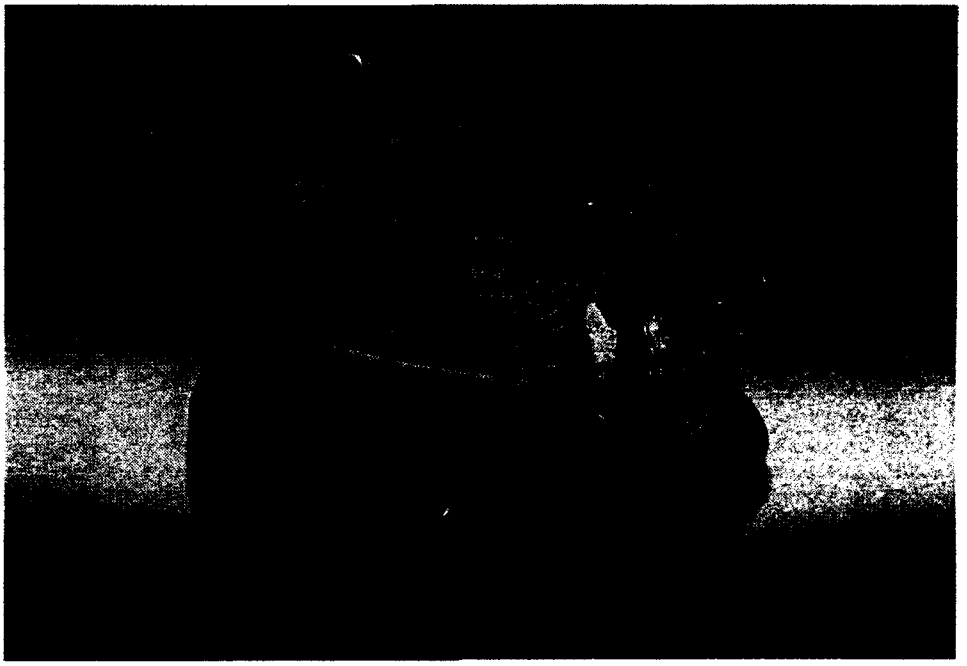


DH-132 CVC Helmet

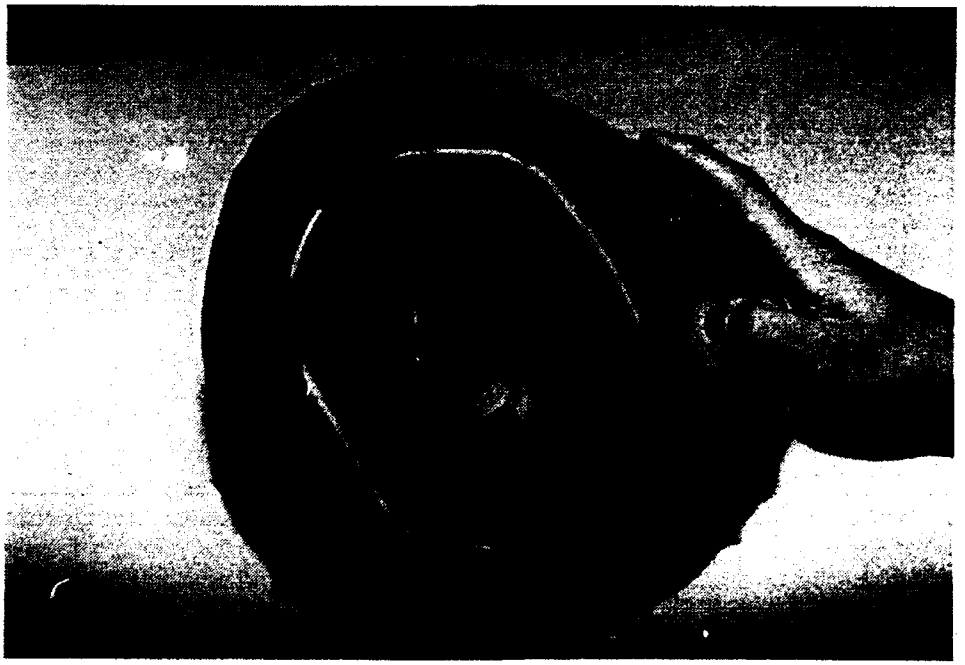
DH-132 CVC Helmet

PASGT Helmet

PASGT Helmet

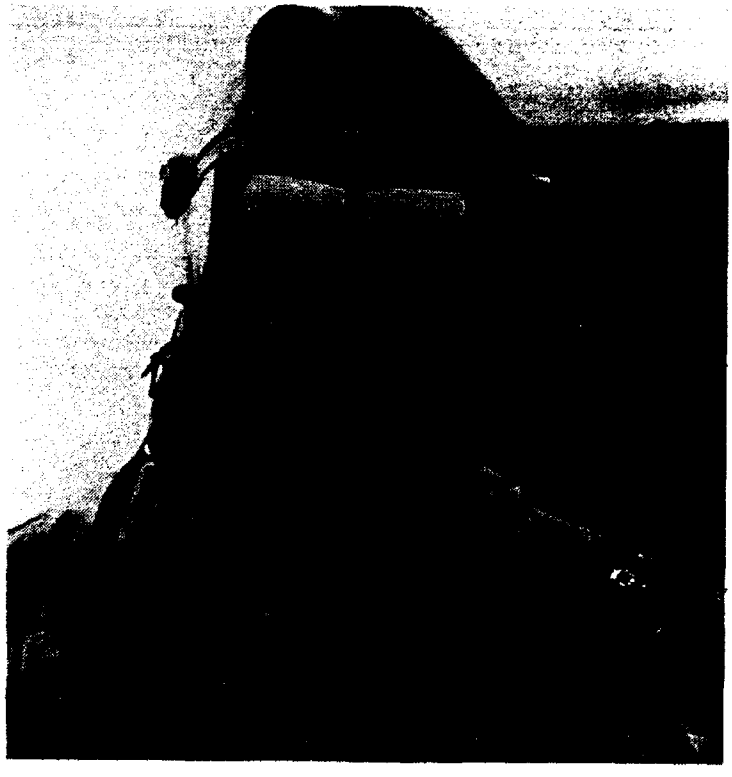


PASGT Helmet



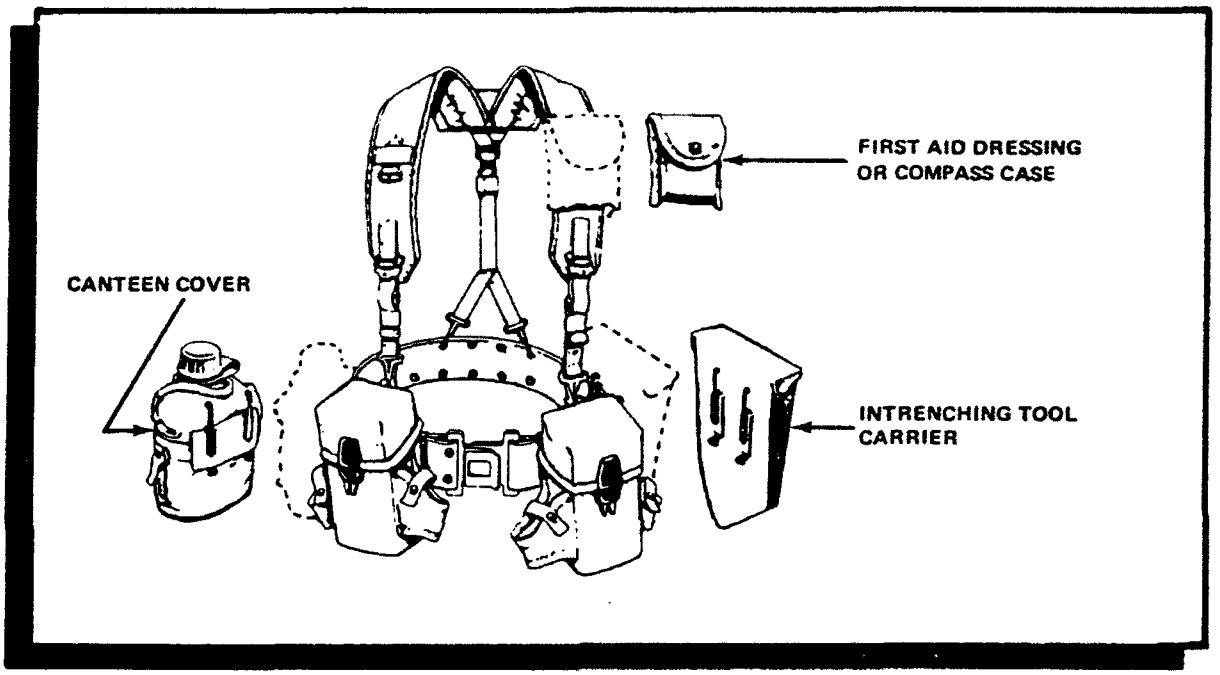
PASGT Helmet

Example of Future Equipment

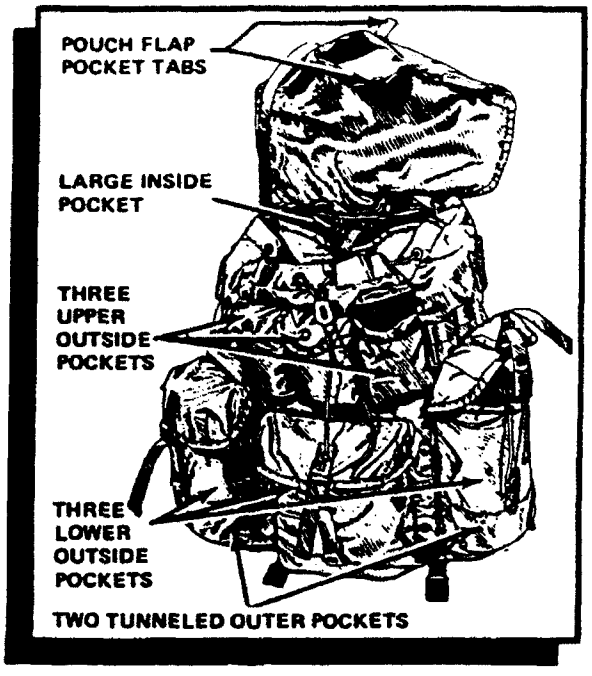


Example of Future Equipment

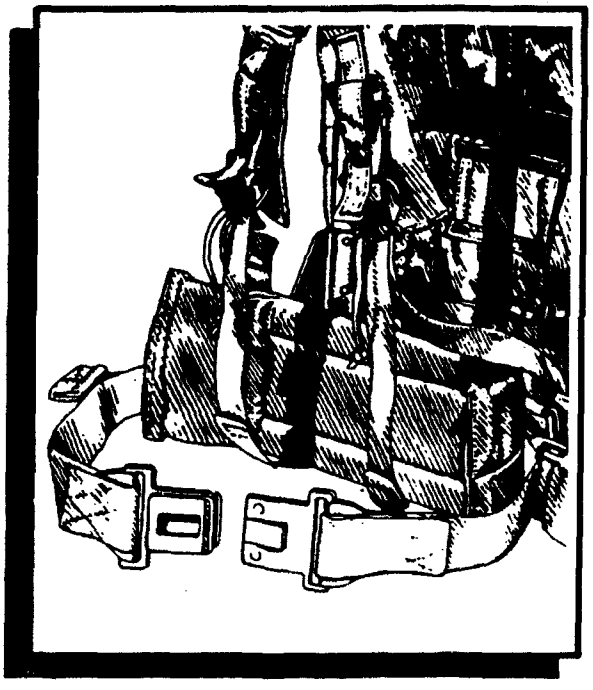
Armor Vest



Individual Equipment Belt and Suspenders with Fighting Load Components



Large Combat Field Pack



Back Strap

Cold-Wet Ensemble

Cold-Dry Ensemble

Night Desert Uniform

Wet Weather Ensemble

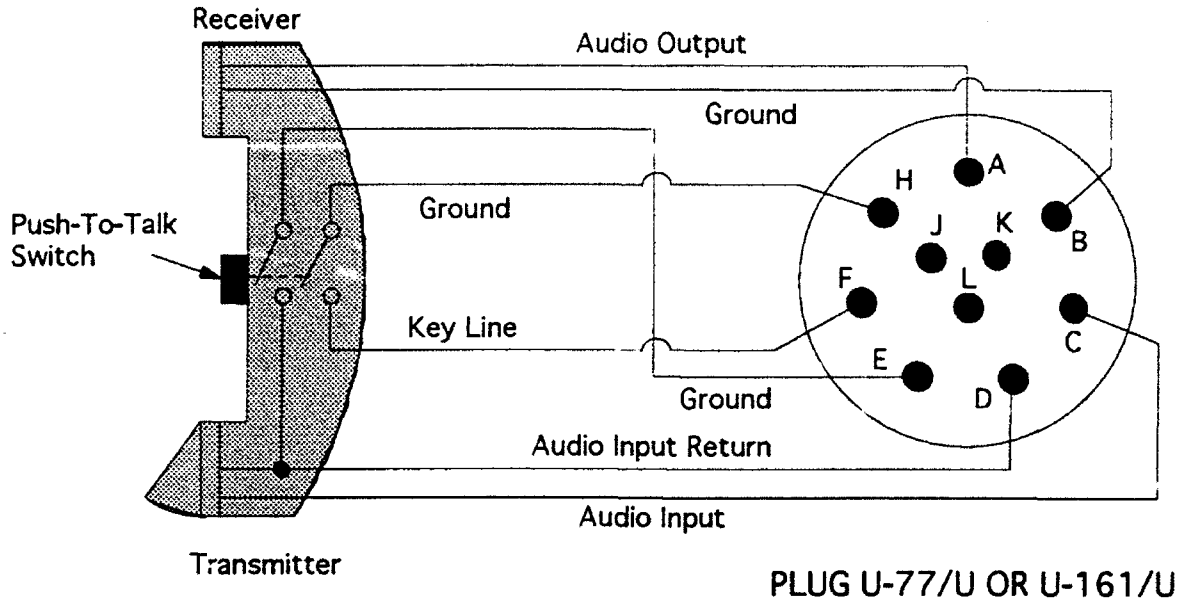
Temperate Uniform

Chemical Protective Ensemble with M17A1 Mask and Hood

Day Desert Uniform

APPENDIX E

Data on Military Ground-Based Communication Equipment



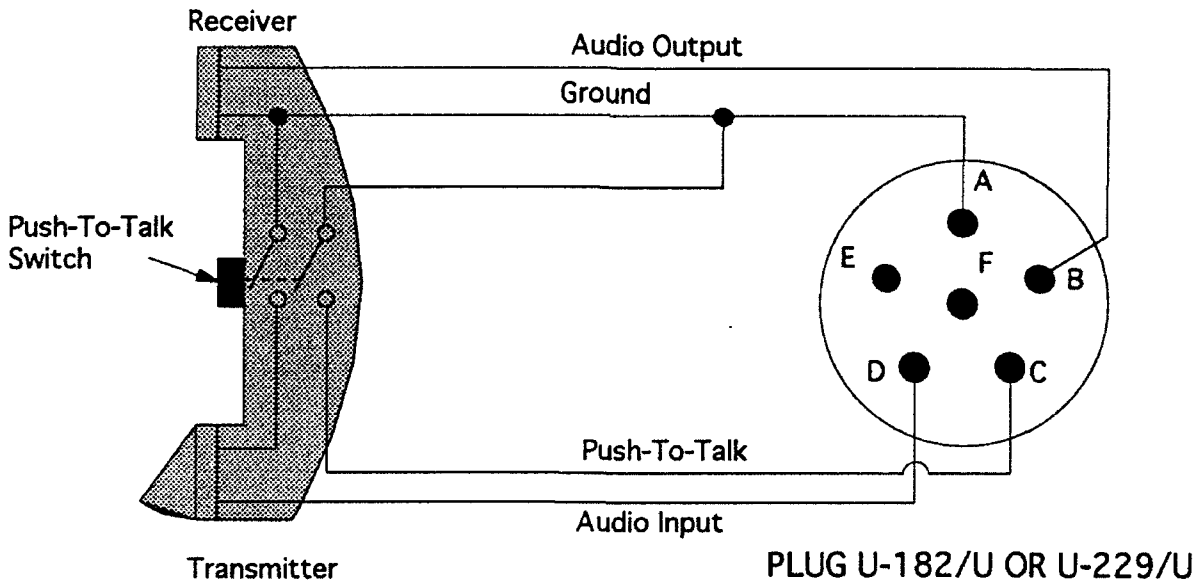


FIGURE E-1. Audio Connectors and Pin-Outs

TABLE E-1. Military Ground-Based Communication Equipment

	Model	Source	Mil-Spec	Access	Description	Accessory	Manufacturer	Contact	Phone
1	AN/FRC-93	TC			PHASED OUT BY 1993, HF-AM commercial radio set	M-127			
2	AN/GRC-9	CD	MIL-R-12252B		OBSOLETE				
3	AN/GRC-10	CD,FSC	MIL-R-10511C	X	OBSOLETE				
4	AN/GRC-19	CD,TC	MIL-R-12454D	X	REPLACED BY AN/GRC-106	H33/PT			
5	AN/GRC-26	CD,FSC	MIL-R-11812A	X	PHASED OUT BY 1993				
6	AN/GRC-27	CD,FSC	MIL-R-26702A	X	OBSOLETE				
7	AN/GRC-41	CD,FSC		X	AM				
8	AN/GRC-50(V)	CD,FSC,TC	MIL-R-55219B		PHASED OUT BY 1993, UHF-FM multichannel				
9	AN/GRC-86	CD,FSC	MIL-R-27095A	X	Radio set				
10	AN/GRC-103(V)	CD,FSC,TC	MIL-R-49023		UHF-FM multichannel				
11	AN/GRC-106	CD,FSC,TC	MIL-R-55238C		PHASED OUT BY 1995, HF-AM SSB Radio set	H33/PT			
12	AN/GRC-109	CD,FSC,TC	MIL-R-55242		HF-AM CW communication				
13	AN/GRC-121	CD,FSC	MIL-R-27752	X					
14	AN/GRC-125,160	TC			REPLACED BY SINCGARS, same comp. as VRC-53,64				
15	AN/GRC-143	TC			FM multichannel tactical radio set				
16	AN/GRC-144	CD,FSC,TC	MIL-R-55333A		FM multichannel LOS communication system				
17	AN/GRC-163	TC			VHF-FM multichannel radio terminal set (RT-524)				
18	AN/GRC-193A	J,TC			HF-AM SSB, same RT as GRC-213, PRC-104	H-189/GR	Harris Corp. RF Comm. Group	Ken Seybolt	716-244-5830
19	AN/GRC-206(V)3	J			HF/VHF/UHF vehicular	H-250/U	Harris Corp/Magnavox Electronic Syst	Ken Seybolt	716-244-5830
20	AN/GRC-211	J			VHF/AM Transceivers		Rockwell Int., Collins Defense Commun.	Joe Murrell ext 5840	319-395-1000
21	AN/GRC-213	J,TC			HF-AM SSB Vehicular version of PRC-104	H-250/U	Hughes Aircraft Co.	Dan Stockton	714-441-9518
22	AN/GRC-220	J			Tactical vehicular	H-250/U	Rockwell Int., Collins Defense Commun.	Joe Murrell ext 5840	319-395-1000
23	AN/GRC-223(V)	J			SSB Tactical radio set	H-250/U	Mackay Communications Inc.	Mike Beck	919-850-3000
24	AN/MRC-2	CD,FSC	MIL-R-13114A	X	Radio set				
25	AN/MRC-5	CD	MIL-R-15972		Radio set				
26	AN/MRC-69	TC			PHASED OUT BY 1993, Radio terminal set, use TRC-24	TA-312/PT			
27	AN/MRC-73	TC			PHASED OUT BY 1993, Radio terminal set, use TRC-24	TA-312/PT			
28	AN/MRC-85,86	CD,FSC	MIL-R-26461	X	Radio set				
29	AN/MRC-100	CD	MIL-R-27756	X					
30	AN/MRC-113	CD,FSC	MIL-R-38503A	X	Radio set				
31	AN/MRC-115	TC			Radio terminal set in shelter, use GRC-103				
32	AN/MRC-127	TC			PHASED OUT BY 1993, Radio terminal set, use GRC-103				

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TABLE E-1. Military Ground-Based Communication Equipment (Continued)

	Model	Source	Mil-Spec	Access	Description	Accessory	Manufacturer	Contact	Phone
33	AN/MRC-138	J			HF, same as GRC-193A	H-250/U	Harris Corp. RF Communications Group	Ken Seybolt	716-244-5830
34	AN/PRC-8,9,10	CD,FSC	MIL-R-10273D	X	Radio set				
35	AN/PRC-17	CD	MIL-R-7121	X	Radio set				
36	AN/PRC-21	CD,FSC	MIL-R-14028A	X	Radio set				
37	AN/PRC-25	CD,FSC,TC	MIL-R-55137C	X	REPLACED BY PRC-119, comp. of VRC-53, GRC-125				
38	AN/PRC-32	CD	MIL-R-19360	X	Radio set				
39	AN/PRC-37	CD	MIL-R-26425	X	Radio set				
40	AN/PRC-41	TC			VHF/UHF-AM single channel RT-695				
41	AN/PRC-47	TC			HF-AM SSB for portable, vehicular or fixed use	H33G/PT			
42	AN/PRC-49	CD	MIL-R-22633A	X	Radio set				
43	AN/PRC-52	CD,FSC	MIL-R-55259	X	Radio set				
44	AN/PRC-63	CD	MIL-R-23959	X	Radio set				
45	AN/PRC-64	TC			HF-AM SSB				
46	AN/PRC-68	CD,FSC,TC	MIL-R-29401B		PHASED OUT BY 1993, Handheld pocket size radio				
47	AN/PRC-58,76	CD,FSC	MIL-R-27144D	X	Radio set				
48	AN/PRC-70	CD,FSC,TC	MIL-R-49118A		PHASED OUT BY 1995, FM manpack	handset			
49	AN/PRC-71	CD	MIL-R-27838	X	Radio set				
50	AN/PRC-72	CD,FSC	MIL-R-27795	X	Radio set				
51	AN/PRC-74	TC			AM SSB				
52	AN/PRC-75B	CD,FSC	MIL-R-82196B		Radio set				
53	AN/PRC-77	CD,FSC,TC	MIL-R-55499B		REPLACED BY PRC-119, comp. of VRC-64, GRC-160	H-250/U	Lucas Hazelton Inc.	Sol Cutler	717-455-7721
54	AN/PRC-104	CD,TC	MIL-R-29418		HF-AM SSB Manpack	H-250/U	Hughes Aircraft Co.	Dan Stockton	714-441-9518
55	AN/PRC-113(V)	J	MIL-R-49304		Manpack,AM, member of GRC-206 family	H-250/U	Magnavox Electronic Systems Co.	George Lapacek	219-429-6155
56	AN/PRC-117A	J	MIL-R-49304		VHF/FM manpack	H-250/U	Harris Corp. RF Communications Group	Ken Seybolt	716-244-5830
57	AN/PRC-119	J,TC			VHF SINCGARS manpack	H-250/U	ITT Corp/ Gen. Dyn. Electronic Div.		516-261-7000
58	AN/PRC-126,128	CD,J	MIL-R-49304		VHF/FM handheld	H-250/U	Magnavox Electronic Systems Co.	John Rasmussen	219-429-6533
59	AN/PRC-127	J			VHF/FM Portable radio	MIC	Bendix/King	Dave Nottingham	913-782-0400
60	AN/PRC-130	J			HF/SSB manpack	H-250/U	Loral Terracom	Joe Arcuri	619-278-4100
61	AN/PRC-132	J			Special Forces radio	H-250/U	Loral Terracom	Joe Arcuri	619-278-4100
62	AN/PSC-3,VSC-7	TC			TACSATCOM radio in shelter or vehicle	H-250/U			
63	AN/SRC-20A,21A	CD	MIL-R-24182A		Radio set				
64	AN/TRC-8	CD,FSC	MIL-R-14497		Radio set				

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TABLE E-1. Military Ground-Based Communication Equipment (Continued)

	Model	Source	Mil-Spec	Access	Description	Accessory	Manufacturer	Contact	Phone
65	AN/TRC-20	CD,FSC			Radio set				
66	AN/TRC-24	CD,FSC,TC	MIL-R-14492	X	VHF/UHF-FM multichannel				
67	AN/TRC-28	CD,FSC	MIL-R-55174	X	Radio set				
68	AN/TRC-29	CD,FSC,TC	MIL-R-13963		PHASED OUT BY 1993, FM multichannel tactical radio				
69	AN/TRC-66	CD,FSC	MIL-R-26434C	X	Radio set				
70	AN/TRC-68	CD,FSC,TC	MIL-R-55016B	X	VHF/UHF AM radio for aircraft ground support				
71	AN/TRC-77	CD,FSC	MIL-R-55253	X	Radio set				
72	AN/TRC-80	TC			PHASED OUT BY 1993, Portable, vehicular or fixed use				
73	AN/TRC-90	TC			PHASED OUT BY 1993, FM radio terminal set in shelter				
74	AN/TRC-92	CD,FSC	MIL-R-27753B	X	Radio set				
75	AN/TRC-103	CD,FSC	MIL-R-27831	X	Radio set				
76	AN/TRC-112	TC			REPLACED BY TRC-170, use GRC-106	TA-312/PT			
77	AN/TRC-117	TC			REPLACED BY TRC-173, use GRC-50				
78	AN/TRC-121	TC			REPLACED BY TRC-170, use GRC-106,143	TA-312/PT			
79	AN/TRC-132	TC			REPLACED BY TRC-170				
80	AN/TRC-133	TC			PHASED OUT BY 1993, Radio terminal set in shelter	TA-312/PT			
81	AN/TRC-145	TC			PHASED OUT BY 1994, Radio terminal set, use GRC-103				
82	AN/TRC-151	TC			REPLACED BY TRC-173, use GRC-103				
83	AN/TRC-170	TC			LOS radio terminal set in shelter, use GRC-197				
84	AN/TRC-173	TC			Radio terminal set in shelter, use GRC-103				
85	AN/TRC-175	TC			Radio terminal set in shelter, use GRC-144				
86	AN/TRC-176	J			Rack-mounted version of PRC-113,GRC-206	H-250/U	Magnavox Electronics Systems Co.	George Lapacek	219-429-6155
87	AN/TRC-181	J			HF		E-Systems Inc.		
88	AN/TRC-879	CD	MIL-R-27138B	X	Radio set				
89	AN/TRQ-35(V)	J			Tactical freq. management				
90	AN/TSC-60(V)7	J			Communication centrals		Rockwell Int., Collins Defense Commun.	Joe Murrell ext 5840	319-395-1000
91	AN/TSC-60(v)8	J			Communication centrals		Rockwell Int., Collins Defense Commun.	Joe Murrell ext 5840	319-395-1000
92	AN/TSC-60(V)9	J			Communication centrals		Rockwell Int., Collins Defense Commun.	Joe Murrell ext 5840	319-395-1000
93	AN/TSC-99	J			Transportable com. system		Rockwell Int., Collins Defense Commun.	Joe Murrell ext 5840	319-395-1000
94	AN/TSC-114	J			Communication system		E-Systems Inc.		
95	AN/TSC-118	J			Communications central		Rockwell Int., Collins Defense Commun.	Joe Murrell ext 5840	319-395-1000
96	AN/TSC-122	J			Transportable HF		Rockwell Int., Collins Defense Commun.	Joe Murrell ext 5840	319-395-1000

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TABLE E-1. Military Ground-Based Communication Equipment (Continued)

	Model	Source	Mil-Spec	Access	Description	Accessory	Manufacturer	Contact	Phone
97	AN/URC-11	CD	MIL-R-8178B	X	Radio set				
98	AN/URC-32	CD,FSC	MIL-R-22723A	X	Radio set				
99	AN/URC-14	CD	MIL-R-26651		Radio set				
100	AN/URC-10	CD	MIL-R-27381B	X	Radio set				
101	AN/URC-35	CD,FSC	MIL-R-28707C		Radio set				
102	AN/URC-60	CD	MIL-R-38467	X	Radio set				
103	AN/URC-64	CD	MIL-R-83237	X	Radio set				
104	AN/URC-75	CD,FSC	MIL-R-81432	X	Radio set				
105	AN/URC-79	J	MIL-R-28823		HF/SSB (DISCONTINUED PRODUCTION)		Scientific Radio Systems Inc.	Feldenmeyer	716-235-2040
106	AN/URC-80	CD,FSC	MIL-R-28823	X	Radio set				
107	AN/URC-87	J	MIL-R-28823		HF/SSB		Southcom International Inc.		
108	AN/URC-92(GSB-9	J	MIL-R-28823		HF/SSB	MIC	Sunair Electronics Inc.	Gary Gearhart	305-525-1505
109	AN/URC-94(RF-28	CD,FSC,J	MIL-R-28848		HF/SSB, VHF/FM	H-250/U	Harris Corp. RF Communications Group	Ken Seybolt	716-244-5830
110	AN/URC-96	J			125 W HF		Southcom International Inc.		
111	AN/URC-100,101	J			Manpack (DISCONTINUED PRODUCTION)	H-250/U	Motorola Government Electronics Group	Mark Wormley	602-441-3033
112	AN/URC-104,111	J			Manpack (DISCONTINUED PRODUCTION)	H-250/U	Motorola Government Electronics Group	Mark Wormley	602-441-3033
113	AN/URC-106(V)	J			Series 125 W HF	H-250/U	Harris Corp. RF Communications Group	Ken Seybolt	716-244-5830
114	AN/URC-110	J			Transceiver (DISCONTINUED PRODUCTION)	H-250/U	Motorola Government Electronics Group	Mark Wormley	602-441-3033
115	AN/URC-112	J			LOS/SATCOM transceiver	H-250/U	Motorola Government Electronics Group	Mark Wormley	602-441-3033
116	AN/URC-119				Series HF radio set	H-250/U	Harris Corp. RF Communications Group	Ken Seybolt	716-244-5830
117	AN/URC-120	J			HF/SSB (DISCONTINUED PRODUCTION)		Cubic Communications	Curtis Riley	619-277-6780
118	AN/VRC-2	CD			Radio set				
119	AN/VRC-12,43-49	J,TC			REPLACED BY SINCGARS, use RT-246,524	H-250/U	Raven Industries Inc.	Adrian Buitendyk	605-336-2750
120	AN/VRC-24	TC			Same as TRC-68				
121	AN/VRC-53,64	TC			REPLACED BY SINCGARS				
122	AN/VRC-83(V)	J			Vehicular	H-250/U	Magnavox Electronics Systems Co.	George Lapacck	219-429-6155
123	AN/VRC-84	J			Vehicular				
124	AN/VRC-86	J			HF vehicular	H-250/U	Bendix/King	Dave Nottingham	913-782-0400
125	AN/VRC 87-92	J,TC			SINCGARS-V	H-250/U	ITT Corp/ Gen. Dyn. Electronic Div.		
126	AN/VRC-94A(V)	J			Series VHF/FM vehicular	H-250/U	Harris Corp. RF Communications Group	Ken Seybolt	716-244-5830
127	VRQ319/BCC39	J			Vehicle/manpack HF		Racal Communications Inc.	Ted Nireman	301-948-4420
128	ERC-320	J			Manpack (DISCONTINUED PRODUCTION)		Ferranti Technologies Inc.		717-285-7151

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TABLE E-1. Military Ground-Based Communication Equipment (Continued)

	Model	Source	Mil-Spec	Access	Description	Accessory	Manufacturer	Contact	Phone
129	ERC 321	J			Manpack (DISCONTINUED PRODUCTION)		Ferranti Technologies Inc.		717-285-7151
130	HST-4A	J			UHF				
131	MSR-8000D	J			HF Transceiver		Mackay Communications Inc	Mike Beck	919-850-3000
132	MSR-8050A	J			HF/SSB Transceiver		Mackay Communications Inc	Mike Beck	919-850-3000
133	MP-25	J			HF/SSB manpack		Kachina Communications Inc.	Al Hugueny	602-282-4837
134	MP-83	J			ECCM VHF/FM		Rockwell Int., Collins Defense Commun.	Joe Murrell ext 5840	319-395-1000
135	PRC1077/GRC-160	J			VHF		Trans World Communications Inc.	Aubrey Stewart ext 500	619-747-1079
136	PR1405-M	J			Handheld VHF		Radio Communications Inc.		
137	PRC1099	J			HF/SSB manpack		Trans World Communications inc.	Aubrey Stewart ext 500	619-747-1079
138	PRM4735	J			Covert personal radio system		Racal Communications Inc.	Ted Nireman	301-948-4420
139	RF-280	J			HF/VHF tactical	H-250/U	Harris Corp. RF Communications Group	Ken Seybolt	716-244-5830
140	RF-301	J			HF tactical	H-250/U	Harris Corp. RF Communications Group	Ken Seybolt	716-244-5830
141	RF-350K	J			Series HF radio systems	H-250/U	Harris Corp. RF Communications Group	Ken Seybolt	716-244-5830
142	RF-1020	J			HF/SSB mobile com. stations		Harris Corp. RF Communications Group	Ken Seybolt	716-244-5830
143	RF-1022	J			Mobile com. stations		Harris Corp. RF Communications Group	Ken Seybolt	716-244-5830
144	RF-2320	J			Transceiver system	H-250/U	Harris Corp. RF Communications Group	Ken Seybolt	716-244-5830
145	RF-3200	J			Series HF/SSB Transceiver	H-250/U	Harris Corp. RF Communications Group	Ken Seybolt	716-244-5830
146	RF-4000	J			Series 400/100 W HF radio	H-250/U	Harris Corp. RF Communications Group	Ken Seybolt	716-244-5830
147	RF-5000	J			HF/SSB digital radio system	H-250/U	Harris Corp. RF Communications Group	Ken Seybolt	716-244-5830
148	RF-7100	J			Communication systems autolink		Harris Corp. RF Communications Group	Ken Seybolt	716-244-5830
149	RF-7166	J			HF data communications system		Harris Corp. RF Communications Group	Ken Seybolt	716-244-5830
150	RF-7200	J			Autolink systems		Harris Corp. RF Communications Group	Ken Seybolt	716-244-5830
151	RS1000 and 400	J			Transportable HF systems		Trans World Communications Inc.	Aubrey Stewart ext 500	619-747-1079
152	RT100/MP	J			HF		Trans World Communications Inc.	Aubrey Stewart ext 500	619-747-1079
153	RT-1101	J			HF/SSB (DISCONTINUED PRODUCTION)		Cubic Communications	Curtis Riley	619-277-6780
154	RT-9000				HF Transceiver		Sunair Electronics Inc.	Gary Gearhart	305-525-1505
155	SC-10				Adaptive HF radio system		Sunair Electronics Inc.	Gary Gearhart	305-525-1505
156	SC106	J			HF/SSB		Southcom International Inc.		
157	SC140	J			HF/SSB		Southcom International Inc.		
158	SG-712EX-11	J			HF/SSB Transceiver		SGC	George Ure	206-746-6310
159	SG-712-S-DE	J			Radiotelephone		SGC	George Ure	206-746-6310
160	SG-715	J			Radiotelephone		SGC	George Ure	206-746-6310

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TABLE E-1. Military Ground-Based Communication Equipment (Continued)

	Model	Source	Mil-Spec	Access	Description	Accessory	Manufacturer	Contact	Phone
161	SR-MP-25	J			Manpack	H-250/U	Scientific Radio Systems	Feldenmeyer	716-235-2040
162	SR-204D	J			HF/SSB Transceiver	H-250/U	Scientific Radio Systems	Feldenmeyer	716-235-2040
163	SR-380M	J			SSB/ISB Transceiver	H-250/U	Scientific Radio Systems	Feldenmeyer	716-235-2040
164	SR-385	J			SSB/ISB Transceiver	H-250/U	Scientific Radio Systems	Feldenmeyer	716-235-2040
165	TW100F(RT-1616/	J			HF	H-250/U	Trans World Communications Inc.	Aubrey Stewart ext 500	619-747-1079
166	VC-120(GRC-220)	J			Vehicular		Rockwell Int., Collins Defense Commun.	Joe Murrell ext 5840	319-395-1000

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TABLE E-2. Condensed List of Military Ground-Based Communication Equipment

	Model	Source	Mil-Spec	Access	Description	Accessory	Manufacturer	Contact	Phone
1	AN/FRC-93	TC			PHASED OUT BY 1993, HF-AM commercial radio set	M-127			
2	AN/GRC-19	CD,TC	MIL-R-12454D	X	REPLACED BY AN/GRC-106	H33/PT			
3	AN/GRC-50(V)	CD,FSC,TC	MIL-R-55219B		PHASED OUT BY 1993, UHF-FM multichannel				
4	N/GRC-103(V)	CD,FSC,TC	MIL-R-49023		UHF-FM multichannel				
5	A.J/GRC-106	CD,FSC,TC	MIL-R-55238C		PHASED OUT BY 1995, HF-AM SSB Radio set	H33/PT			
6	AN/GRC-109	CD,FSC,TC	MIL-R-55242		HF-AM CW communication				
7	AN/GRC-125,160	TC			REPLACED BY SINCGARS, same comp. as VRC-53,64				
8	AN/GRC-143	TC			FM multichannel tactical radio set				
9	AN/GRC-144	CD,FSC,TC	MIL-R-55333A		FM multichannel LOS communication system				
10	AN/GRC-163	TC			VHF-FM multichannel radio terminal set (RT-524)				
11	AN/GRC-193A	J,TC			HF-AM SSB, same RT as GRC-213, PRC-104	H-189/GR	Harris Corp. RF Comm. Group	Ken Seybolt	716-244-5830
12	AN/GRC-206(V)	J			HF/VHF/UHF vehicular	H-250/U	Harris Corp/Magnavox Electronic S	Ken Seybolt	716-244-5830
13	AN/GRC-213	J,TC			HF-AM SSB Vehicular version of PRC-104	H-250/U	Hughes Aircraft Co.	Dan Stockton	714-441-9518
14	AN/GRC-220	J			Tactical vehicular	H-250/U	Rockwell Int., Collins Defense Comn	Joe Murrell ext 5840	319-395-1000
15	AN/GRC-223(V)	J			SSB Tactical radio set	H-250/U	Mackay Communications Inc.	Mike Beck	919-850-3000
16	AN/MRC-69	TC			PHASED OUT BY 1993, Radio terminal set, use TRC-24	TA-312/PT			
17	AN/MRC-73	TC			PHASED OUT BY 1993, Radio terminal set, use TRC-24	TA-312/PT			
18	AN/MRC-115	TC			Radio terminal set in shelter, use GRC-103				
19	AN/MRC-127	TC			PHASED OUT BY 1993, Radio terminal set, use GRC-103				
20	AN/MRC-138	J			HF, same as GRC-193A	H-250/U	Harris Corp. RF Communications Gr	Ken Seybolt	716-244-5830
21	AN/PRC-25	CD,FSC,TC	MIL-R-55137C	X	REPLACED BY PRC-119, comp. of VRC-53, GRC-125				
22	AN/PRC-41	TC			VHF/UHF-AM single channel RT-695				
23	AN/PRC-47	TC			HF-AM SSB for portable, vehicular or fixed use	H33G/PT			
24	AN/PRC-64	TC			HF-AM SSB				
25	AN/PRC-68	CD,FSC,TC	MIL-R-29401B		PHASED OUT BY 1993, Handheld pocket size radio				
26	AN/PRC-70	CD,FSC,TC	MIL-R-49118A		PHASED OUT BY 1995, FM manpack	handset			
27	AN/PRC-74	TC			AM SSB				
28	AN/PRC-77	CD,FSC,TC	MIL-R-55499B		REPLACED BY PRC-119, comp. of VRC-64, GRC-160	H-250/U	Lucas Hazelton Inc.	Sol Cutler	717-455-7721
29	AN/PRC-104	CD,TC	MIL-R-29418		HF-AM SSB Manpack	H-250/U	Hughes Aircraft Co.	Dan Stockton	714-441-9518
30	AN/PRC-113(V)	J	MIL-R-49304		Manpack,AM, member of GRC-206 family	H-250/U	Magnavox Electronic Systems Co.	George Lapacek	219-429-6155

CD - CD ROM, FSC - Federal Sur .. Class Index, J - Jane's Military Communications, TC - Training Circular 24-24, X - MIL SPEC has cancelled notice

TABLE E-2. Condensed List of Military Ground-Based Communication Equipment (Continued)

	Model	Source	Mil-Spec	Access	Description	Accessory	Manufacturer	Contact	Phone
31	AN/PRC-117A	J	MIL-R-49304		VHF/FM manpack	H-250/U	Harris Corp. RF Communications Gr	Ken Seybolt	716-244-5830
32	AN/PRC-119	J,TC			VHF SINCGARS manpack	H-250/U	ITT Corp/ Gen. Dyn. Electronic Div.		516-261-7000
33	AN/PRC-127	J			VHF/FM Portable radio	MIC	Bendix/King	Dave Nottingham	913-782-0400
34	AN/PRC-130	J			HF/SSB manpack	H-250/U	Loral Terracom	Joe Arcuri	619-278-4100
35	AN/PRC-132	J			Special Forces radio	H-250/U	Loral Terracom	Joe Arcuri	619-278-4100
36	AN/PSC-3,VSC-7	TC			TACSATCOM radio in shelter or vehicle	H-250/U			
37	AN/TRC-24	CD,FSC,TC	MIL-R-14492	X	VHF/UHF-FM multichannel				
38	AN/TRC-29	CD,FSC,TC	MIL-R-13963		PHASED OUT BY 1993, FM multichannel tactical radio				
39	AN/TRC-68	CD,FSC,TC	MIL-R-55016B	X	VHF/UHF AM radio for aircraft ground support				
40	AN/TRC-80	TC			PHASED OUT BY 1993, Portable, vehicular or fixed use				
41	AN/TRC-90	TC			PHASED OUT BY 1993, FM radio terminal set in shelter				
42	AN/TRC-112	TC			REPLACED BY TRC-170, use GRC-106	TA-312/PT			
43	AN/TRC-117	TC			REPLACED BY TRC-173, use GRC-50				
44	AN/TRC-121	TC			REPLACED BY TRC-170, use GRC-106,143	TA-312/PT			
45	AN/TRC-132	TC			REPLACED BY TRC-170				
46	AN/TRC-133	TC			PHASED OUT BY 1993, Radio terminal set in shelter	TA-312/PT			
47	AN/TRC-145	TC			PHASED OUT BY 1994, Radio terminal set, use GRC-103				
48	AN/TRC-151	TC			REPLACED BY TRC-173, use GRC-103				
49	AN/TRC-170	TC			LOS radio terminal set in shelter, use GRC-197				
50	AN/TRC-173	TC			Radio terminal set in shelter, use GRC-103				
51	AN/TRC-175	TC			Radio terminal set in shelter, use GRC-144				
52	AN/TRC-176	J			Rack-mounted version of PRC-113,GRC-206	H-250/U	Magnavox Electronics Systems Co.	George Lapacek	219-429-6155
53	AN/TRC-181	J			HF		E-Systems Inc.		
54	AN/VRC-12,43-49	J,TC			REPLACED BY SINCGARS, use RT-246,524	H-250/U	Raven Industries Inc.	Adrian Buitendyk	605-336-2750
55	AN/VRC-24	TC			Same as TRC-68				
56	AN/VRC-53,64	TC			REPLACED BY SINCGARS				
57	AN/VRC 87-92	J,TC			SINCGARS-V	H-250/U	ITT Corp/ Gen. Dyn. Electronic Div.		

CD - CD ROM, FSC - Federal Supply Class Index, J - Jane's Military Communications, TC - Training Circular 24-24, X - MIL SPEC has cancelled notice

TABLE E-3. Audio Accessories for Military Radios

Audio Accessory	Description	Connector
H-33()/pt	Handset	U-161/U
H-227()/U	Headset	U-161/U
M-29()/U	Carbon Microphone	U-161/U
H-139/GR	Headset	U-182/U
H-140()/GR	Headset	U-182/U
H-141()/GR	Headset-Chestset	U-182/U
H-161()/GR	Headset-Microphone	U-182/U
H-138()/GR	Handset	U-182/U
M-80/U	Microphone Unit	U-182/U
M-81()/GR	Microphone Unit	U-182/U
M-138()/GR	Dynamic Microphone	U-182/U
H-189/GR	Handset	U-229/U
H-250/U	Handset	U-229/U
TA-312A/PT	Field Telephone Set	U-229/U

TABLE E-4. Military Radio Pin-Outs

Model	Handset/ Connector	Pin	Signal Name	Signal Type	Signal Characteristics	Input Impedance	External Load Impedance	Source	Comments
H-189/GR		A	Ground	Ground				MIL-R-49078	The H-250/U supercedes and is
H-250/U		B	Audio RCVR	Analog Output	Response : 20-3500Hz, 104-110 dB at 0.0002 dyne/cm2 with 1mW applied		1000 ohms +/-10%		compatible with the H-189/GR.
(HANDSETS)		C	Push-To-Talk	Control Input	Grounding this line keys transmitter in the RT unit				The microphone is dynamic.
		D	Audio XMT	Analog Input	Response : -56dBm(0.613mVrms) min with 1000Hz input of 28 dynes/cm2	150 ohms +/-10%			
		E							
		F							
AN/GRC-213	H-189/GR	A	Ground	Ground				Phone convers.	
AN/GRC-193	U-229/U	B	Audio RCVR	Analog Output	Response : 500-3000Hz, +/-3dB @1000Hz ref; Power : 2mW min.		500 ohms		
AN/MRC-138	6 pin	C	Push-To-Talk	Control Input	XMT=0V,RCV=open at 28VDC				
AN/PRC-104		D	Audio XMT	Analog Input	Input Levels : 500-3000Hz, -56dBm(.613mVrms)	150 ohms			
		E	CW Key						
		F	Special Purpose						
AN/GRC-223	H-250/U	A	Ground	Ground				Phone convers.	
	U-229/U	B	Audio RCVR	Analog Output	Response : 300-3000Hz, +/-3dB @1000Hz ref; Power : 10mW		600 ohms		
	5 pin	C	Push-To-Talk	Control Input	XMT=0V,RCV=open at 9VDC				
		D	Audio XMT	Analog Input	Input Levels : 300-3000Hz, -51.8dBm(1mVrms)/-5.7dBm(200mVrms)	150 ohms			
		E							
		F							
AN/PRC-68	H-250/U	A	Ground	Ground				MIL-R-29401B	Contains internal mic and speaker
	U-229/U	B	Audio RCVR	Analog Output	Response : 300-3000Hz, +1/-4 dB @1000Hz ref; Power : 20 mW min				
	5 or 6 pin	C	Push-To-Talk	Control Input					
		D	Audio XMT	Analog Input					
		E	Power Interface		External +15VDC power interface for vehicular installations				
		F							
AN/PRC-77	H-250/U	A	Ground	Ground				Catalog	
	U-229/U	B	Audio RCVR	Analog Output	Response : 300-3000Hz, +3/-6dB @1000Hz ref; Power : 4mW		1000 ohms		
		C	Push-To-Talk	Control Input					
		D	Audio XMT	Analog Input	Input Levels : 300-3000Hz, -48.8dBm(1.4mVrms)/-34.8dBm(7.0mVrms)	150 ohms			
		E							
		F							
AN/PRC-113	H-250/U	A	Ground	Ground				Spec sheet	
AN/TRC-176	U-229/U	B	Audio RCVR	Analog Output	Response : 300-3500Hz, +1/-2 dB @1000Hz ref; Power : 10mW		1000 ohms		
AN/VRC-83		C	Push-To-Talk	Control Input	XMT=0V,RCV=open at 5.5VDC; grounding this line keys transmitter				
		D	Audio XMT	Analog Input	Input Levels : 300-3500Hz, -46.7dBm(1.8mVrms)/-19.7dBm(40mVrms)	150 ohms			
		E	Plain/Cipher	Digital Input	Control line from external COMSEC equipment or external data terminal				
		F	RCVR Digital Output	Digital Output	Output to external COMSEC equipment or external data terminal				

TABLE E-4. Military Radio Pin-Outs (Continued)

Model	Handset/ Connector	Pin	Signal Name	Signal Type	Signal Characteristics	Input Impedance	External Load Impedance	Source	Comments
AN/PRC-126 AN/PRC-128	H-250/U U-229/U 6 pin	A B C D E F	Ground Audio RCVR Push-To-Talk Audio XMT	Ground Analog Output Control Input Analog Input	Response : 300-3000Hz, +1/-6 dB @1000Hz ref			MIL-R-49304	Contains internal mic and speaker
AN/PRC-130 AN/PRC-132	H-250/U U-229/U 6 pin	A B C D E F	Ground Audio RCVR Push-To-Talk Audio XMT CW Key Special Purpose	Ground Analog Output Control Input Analog Input	Response : 300-3000Hz; Power : 10mW min XMT=0V,RCV=open at 12VDC Input Levels : 300-3000Hz, -57.8dBm(0.5mVrms)/-17.8dBm(50mVrms) Power 12V accessory equipment or used for remote control input	150 ohms	500 ohms	Phone convers.	Compatible with H-161C/U speaker-mic headset with phone plug (need U-229/U connector) and H-140B/U mic-only headset (for CW keying)
AN/URC-94	H-189/GR	A B C D E F	Ground Audio RCVR Push-To-Talk Audio XMT	Ground Analog Output Control Input Analog Input	Response : 500-3000Hz, +/-3 dB @1000Hz ref; Power : Accepts input from either a dynamic or a carbon mic		600 ohms +/-20%	MIL-R-28848	
AN/VRC-86	H-250/U U-229/U U-183/U	A B C D E F	Ground Audio RCVR Push-To-Talk Audio XMT NA NA	Ground Analog Output Control Input Analog Input	Response : 350-3050Hz, <5dB; Power : 50mW Input Levels : 300-3000Hz, -56dBm(.613mVrms)	150 ohms		Spec sheet	
AN/PRC-119 AN/VRC-87, 88,89,90, 91,92 (SINCGARS)	H-250/U U-229/U U-183/U	A B C D E F	Ground Audio RCVR Push-To-Talk Audio XMT Fill Information NA	Ground Analog Output Control Input Analog Input Digital Input	Response : 300-3000Hz, +2/-3 dB @1000Hz ref; Powet : 50mW XMT = 0V +/- 0.5V, RCV = open, pin held at 1.2VDC internally Input Levels : 300-3000Hz, -48.8dBm(1.4mVrms)/-3.8dBm(250mVrms) Digital Clock 1=-6.75V,-0.5V/+1V; 0=0V+/-0.5V	150 ohms	600 ohms	Spec sheet	PTT requires <1kohms external load to activate input and >5kohms to inactivate

APPENDIX F

Examples of Using Optical Devices with Respiratory Protective Apparel

Example of Using Optical Device with Respiratory Protective Mask

Example of Using Optical Device with Respiratory Protective Mask

APPENDIX G

Illustration of AN/PVS-5C Night Vision Goggles

FIGURE G-1. AN/PVS-5C Night Vision Goggle (NVG) Front View

FIGURE G-2. AN/PVS-5C NVG Back View

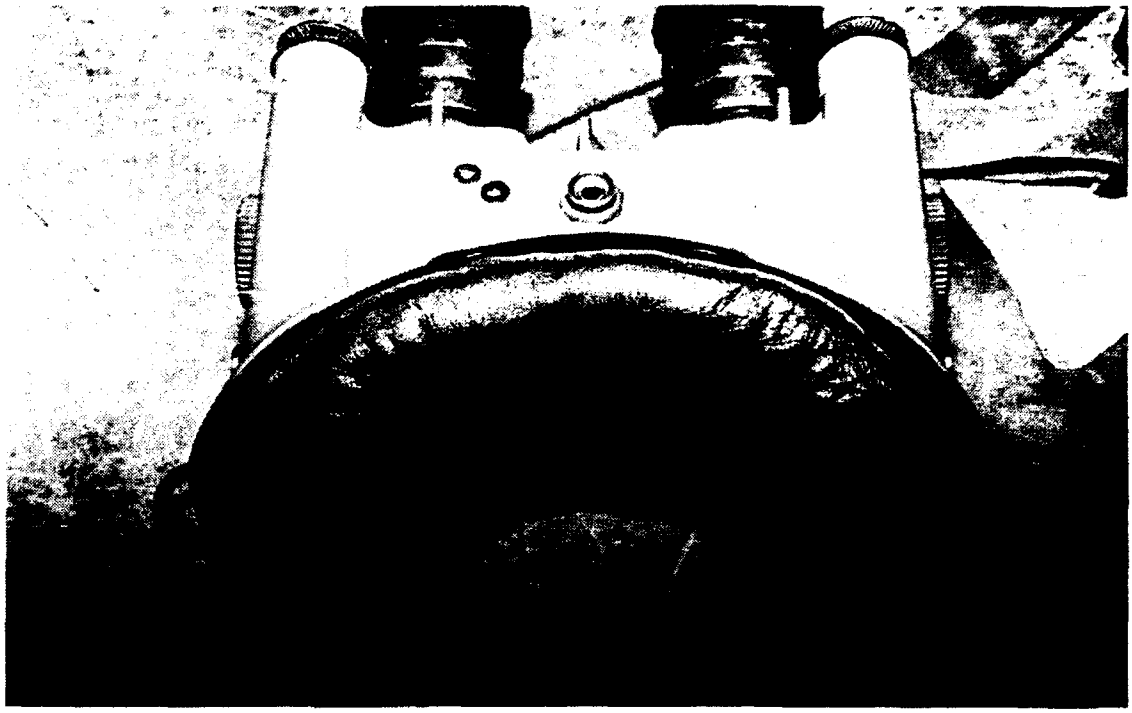

FIGURE G-3. AN/PVS-5C NVG Top View Displaying Face Pad Geometry

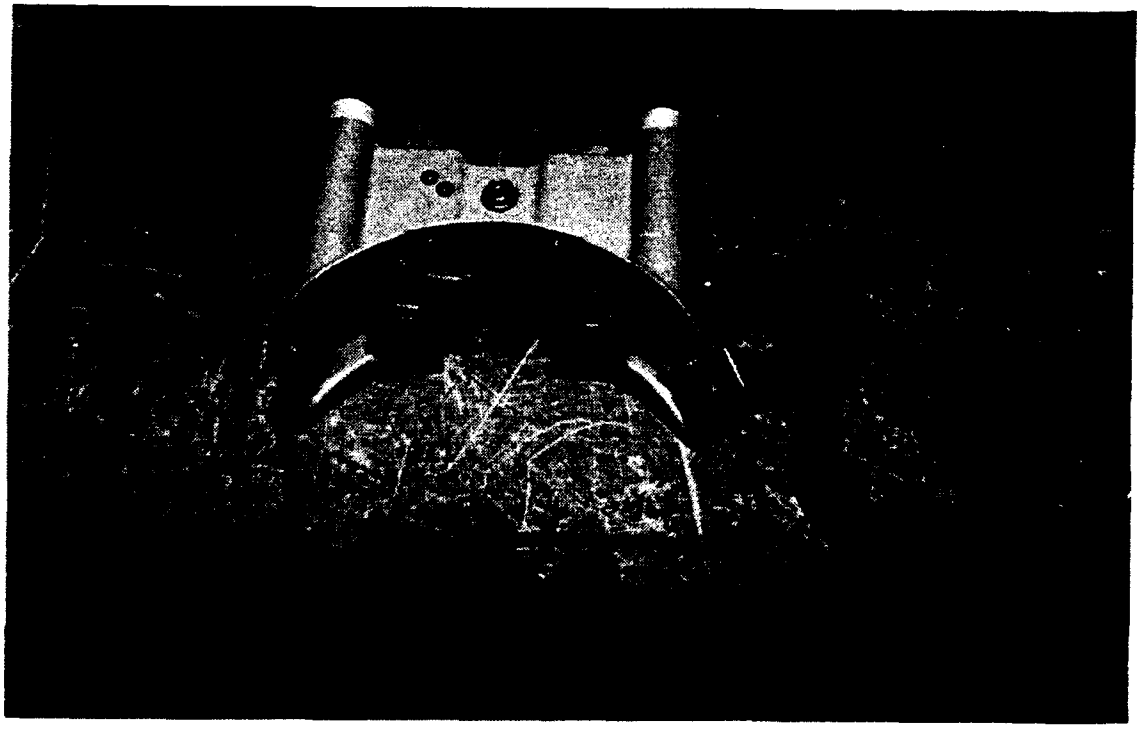

FIGURE G-4. AN/PVS-5C NVG Top View Without Face Pad

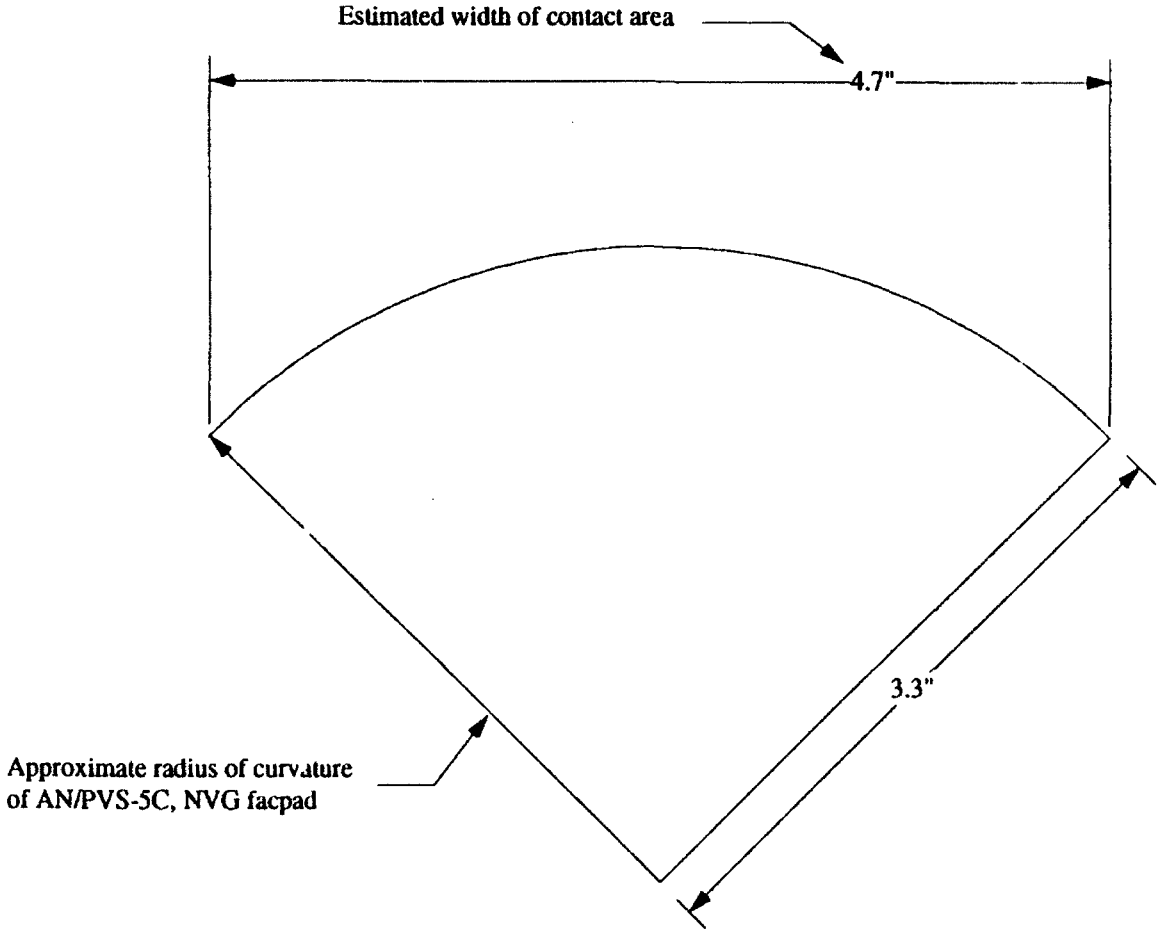

FIGURE G-5. Approximate Radius of Curvature for AN/PVS 5C NVG Face Pad