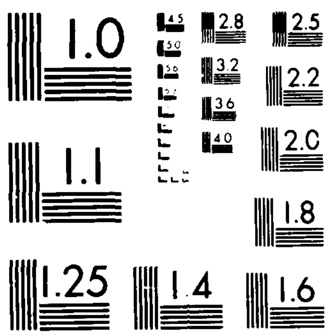
AD-A177 404 AUDITORY EVOKED POTENTIALS AS A FUNCTION OF SLEEP DEPRIVATION AND RECOVER..(U) BOWLING GREEN STATE UNIV OH DEPT OF PSYCHOLOGY P BADIA ET AL. 29 SEP 85 1/1

UNCLASSIFIED DAMD17-84-C-4004 F/G 5/10 NL

END
4 87
DTIC



MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS 1963 A

AD-A177 484

AUDITORY EVOKED POTENTIALS AS A FUNCTION OF SLEEP DEPRIVATION AND RECOVERY SLEEP

ADDENDUM

Final Report

September 29, 1985

Pietro Badia
John Harsh

Supported by

U. S. ARMY MEDICAL RESEARCH AND DEVELOPMENT COMMAND
Fort Detrick, Frederick, Maryland 21701-5012

Contract No. DAMD17-84-C-4084

Bowling Green State University
Bowling Green, Ohio 43403

DOD DISTRIBUTION STATEMENT

Approved for public release; distribution unlimited

The findings in this report are not to be construed as an official Department of the Army position unless so designated by other authorized documents.

TABLE OF CONTENTS

1.0 INTRODUCTION

This report describes research completed for the U. S. Army Aeromedical Research Laboratory (USAARL) by members of the departments of Psychology at Bowling Green State University and the University of Southern Mississippi under the direction of Dr. Pietro Badia and Dr. John Harsh, respectively. The work was completed at the U. S. Army Human Engineering Laboratory (USAHEL), Aberdeen, Maryland and at the University locations. The aim of the work was to assist USAARL in exploratory research directed at identifying, describing, and measuring psychophysiological phenomena associated with work/rest cycles during extended military operations. The specific tasks were to:

(1) Provide trained personnel to assist in the development of data collection procedures and to assist in actual data collection at USAHEL;

(2) produce a methodological report on the appropriate method of electrode placements for accurate sleep stage recordings;

(3) produce an evaluation report of USAARL's prototype SASSSY (Psychophysiological Data Retrieval, Storage, and Analysis System; Telefactor Corp.); and

(4) produce a final report of exploratory data collected at USAHEL.

2.0 ACTIVITIES OF UNIVERSITY PERSONNEL AT USAHEL

University personnel (five individuals) provided assistance in the development of data acquisition procedures and assisted in the collection of data at USAHEL during the period April 29, to June 8, 1985. All personnel were trained in procedures for the acquisition and analysis of psychophysiological data and were expert in the area of polysomnographic recordings used in the study of sleep. Two members of the groups also possessed electronic and computer programming skills. The University personnel:

(1) Assisted in all phases of data collection involving electroencephalographic, electrooculographic, and electromyographic measures during periods of extended operations and during recovery sleep;

(2) developed and implemented methodology to experimentally validate different electrode montages for determination of sleep/wake periods of tank crew members wearing chemical defense ensembles;

(3) evaluated electrode placement and application techniques for several sleep recording montages;

(4) contributed to field testing of SASSSY and worked with manufacturer to correct hardware and software flaws and to improve deficiencies; and

(5) made changes in SASSSY software to conform to needs of field settings and suggested addtional one to manufacturer.

3.0 RECOMMENDATIONS REGARDING ELETRODE PLACEMENT AND INSTRUMENT (SASSSY) SETTINGS FOR SLEEP STAGE RECORDING

The following recommendations are made regarding the use of the SASSSY system to obtain psychophysiological data in a field setting where: (a) Information is desired about levels of alertness during extended operations and (b) only a small number of electrode placements can be used.

3.1 Electroencephalographic Measures

For detection of sleep or electrophysiological correlates (e.g., alpha bursts) of reduced vigilance during periods of extended operations, it is recommended that electroencephalographic (EEG) recordings be obtained using two derivations. All of the information needed for the scoring of sleep stages can normally be obtained from either C3/A2 or C4/A1 (see Rechtschaffen and Kales, 1968). An additional derivation, O1/A2 or O2/A1, is recommended primarily for the detection of alpha rhythm which is related to reduced vigilance during wakefulness. Although alpha rhythm is normally seen in the central derivations, it is more prominent in the occipital area and is therefore less likely to be obscured by movement and other artifact. The mastoid ipsilateral to the EEG electrodes can be used as a ground. General recording procedures should follow those described in Rechtschaffen and Kales (1968). For the SASSSY system, a sensitivity of 9-12 dB for these two recording channels is recommended. The maximum sample rate (currently 100/s) is recommended. We should note that a greater sampling rate would be highly desirable where fine resolution of waveforms is required.

3.2 Electrooculographic Measures

It is advantageous to have two channels for the recording of eye movement activity. This allows for the detection of signals that are often confused for eye movements and provides for more valid scoring of Rapid Eye Movement (REM) sleep. When it is essential, to minimize the number of electrodes used, a single electrode (with the same referent as the EEGs) placed at the outer canthus of one eye is sufficient. This may make it more difficult to score stage REM sleep but should have only a marginal effect on the scoring of signs of sleep onset in subjects who are supposed to be awake. For the SASSSY a sensitivity of 9-12 dB (as above) should be used. General recording and interpretation procedures should follow those described in Rechtschaffen and Kales (1968).

3.3 Electromyographic Measures

Where possible, the procedures for placement of electrodes and for recording and interpretation of EMG data should be consistent with those described in Rechtshaffen and Kales (1968). However, in the project described in this report, there was concern that the chemical defense ensembles worn by the crew members would create problems in the placement of electrodes and four different placements were evaluated for EMG recordings. These included: Submental, deltoid, frontalis, and neck (approximately 1" below the inion). The submental placements are conventional for sleep staging. Use of gas masks, however, often created problems in the use of this placement and the neck placement was the clear second choice. This placement can be considered valid only for the detection of movement and related artifact in other channels.

For SASSSY, sensitivity should be set at 9-12 dB and a sampling rate of 50/sec will result in an accurate and scorable tracing. In conclusion, a montage similar to that described in Rechtschaffen and Kales (1968) is recommended for the scoring of sleep stages. Either C4/A1 or C3/A2 must be used. An additional derivation using an occipital area is helpful in the detection of alpha rhythm. Where possible additional placements are recommended to (1) provide for a second EOG channel, (2) provide a "back up" for the EEG recordings, and (3) provide information to explore regional differences in EEG changes associated with sleep onset and/or loss of alertness.

4.0 EVALUATION OF USAARL'S PROTOTYPE SASSSY

4.1 SASSSY Documentation

The following recommendations are based on use of the system in recording data at USAHEL and in the analysis of data at the University labs. Generally, more complete instructions on the operation of the system would be helpful. In many cases, critical information was available only through a telephone call to the manufacturer.

4.1.1 General Comments

(a) There should be an index of system commands, error codes, and a full explanation of each.

(b) There should be a glossary of terms, especially for terms like "soft keypad", "montage", "tape streamer", etc. for easy reference.

(c) It would be helpful to have a more thorough discussion of editing montages and how each parameter works (pp. 12-13). There was some confusion as to the functions of the "edit" and "mont" modes in the creation, editing and filing of montages. There should be more emphasis on reminding the user to file montages.

(d) An extensive debugging section in the SASSSY System manual would might be extremely helpful. Explanations of the use of PRESERVE.EXE and SHOWERR.COM (Sysgen utility programs) in connection with the SASSSY are needed.

4.1.2 Scoring Procedures

(a) Page 18. It should be made clear that the name of the scoring file does not have to be the same as the "scored data file name" entered while recording data. This lack of clarity results in confusion.

(b) Page 20. "scoring comments". It should be made clearer where scoring comments will appear when page is accessed (they appear at the bottom of the control display).

(c) The "manual keypad" section (p.20) is obsolete and should be excised.

(d) A graphic representation of the scoring screen with accompanying remarks, as there is with the record mode, would be very helpful.

(e) Explanation of T-Box data from the new system software is missing. A "T-F1" and "C-F1" must be performed in succession in order to suppress the T-BOX display field. This is not explained adequately on page 22.

(f) "Print EEG" section needs updating: does not explain that it is accessed from F1 of the secondary system menu (p. 22). On page 23, the top paragraph reads: "the program prompts the operator with the question, 'all pages entered (Y or N). Typing a 'Y' start the printing process." Should be amended to read: "...typing a 'Y' will display a prompt asking if the user wishes to save the page in a file. If 'Y' then specify file name."

(g) The inputs listed on page 23 under "Report Generation" do not correspond with the latest system version (numbers 5-11 listed in the manual do not appear). It should be made clear that these are examples of prompts and may be modified for user purposes.

4.1.3. Reformatter

(a) Again, an index and summary of controls (e.g., trace brightness, polarity, sample rate, etc.) should be included for quick reference.

4.2 Software Problems

(a) The secondary menu looks too much like the main system menu. Example: Performing an "F4" from what the user thinks is the main menu ("load data to disk") when actually in the secondary menu ("load system software") will dump data from tape to vol. C, where the system files reside, The PRESERVE utility must then be used to restore vol. c (this should be addressed in the documentation, see SASSSY DOCUMENTATION, no. 11).

(b) There should be vertical "voltage" markers in the scoring display in order to facilitate differentiation of low and high voltage waves.

(c) The 10-sec page mode (1st, 2nd, 3rd) does not always correspond to the 30 sec page (i.e., at times they are not in the correct order). Note that this problem occurred with only one of the two systems we tested.

4.3 General Recommendations

(a) Increase the capacity of the hard disk to allow for more than approx. 4 hours of data collection (when 16 channels are used).

(b) Montage, time, and page numbers should be able to be displayed on the screen in both the 30-s and 10-s page mode. Currently, these can only be displayed in the mode in effect when the information was stored. Also the montage, time, and page number should be displayed continuously (instead of only when the "M,F1" command is used to display it for one page). The montage text should be smaller to avoid obscuring the signals.

(c) The software controls for sensitivity and offset could be more efficiently changed than with the current procedure using the "O,G,F1" commands one channel at a time.

(d) Overall, while scorable, the signals lack the resolution one would expect from such an expensive system.

5.0 REPORT ON EXPLORATORY DATA COLLECTED AT USAHEL

Psychophysiological data were obtained during phase IV of the Department of the Army's P NBC Tank Systems Climate-Controlled Trials (Iron Man) which was conducted at the U. S. Army Human Engineering Laboratory (USAHEL). The purpose of these trials was to assess the value of proposed changes in equipment and tasks to enhance the capabilities of tank systems. Four-man M1 tank crews wearing chemical defense ensembles (MOPP IV) were tested in a temperature-controlled environment during a tactical scenario which was to last no longer than 72 hours.

The contract under which the data to be described were collected called for aiding USAARL in exploratory research directed at identifying, measuring, and describing psychophysiological phenomena associated with work/rest cycles during extended military operations. The following questions were addressed:

(1) Can psychophysiological measures (especially CNS measures) be efficiently and reliably obtained during work/rest cycles of an extended military operation?

(2) Can psychophysiological variables be used to assess levels of alertness of personnel during work/rest cycles of an extended military operation?

(3) Can studies of the recovery sleep of personnel participating in the extended operations be used to assess the effects of extended operations and/or provide information with which to evaluate the consequences of changes in equipment and/or tasks?

5.1 Methods

Data were collected from each member of a four-man tank crew during each of six replications for a total of 24 subjects. The positions assumed by the crew members were that of Tank Commander, Driver, Loader, and Gunner.

The equipment used was USAARL's prototype SASSSY (Psychophysiological Data Retrieval, Storage, and Analysis System; Telefactor Corp.) with preamplifiers, amplifiers, and other peripheral equipment necessary to monitor psychophysiological variables at a location external to the tank environment.

Psychophysiological measures were continuously obtained during the time that the subjects were in the tank and also during the recovery sleep period following the vigil (the time from first entry into the tank until the final exit). Electroencephalographic (EEG), electrooculographic (EOG), and electromyographic (EMG) measures were obtained

5.2 Results and Conclusions

5.2.1 Monitoring of Psychophysiological Variables During Extended Operations

Psychophysiological variables can be continuously monitored during work/rest cycles of extended military operations of the type described in this report. Although the quality of the recordings was not generally sufficient to permit reliable analysis of brief changes in the EEG that may have been associated with reduced alertness during wakefulness, a substantial portion of the EEG, EOG, and EMG data obtained was of sufficient quality to permit the scoring of sleep/wake stages following conventional scoring procedures (Rechtschaffen & Kales, 1968). Further, these measures were taken with minimal discomfort to personnel and with minimal interference with the crew members' activities.

Some problems were encountered in the collection of data. During the first two replications, an insufficient amount of usable data was obtained to permit careful analysis mainly because of hardware problems related to the SASSSY system. Many of these problems, were identified and corrected by USAARL, University, and Telefactor personnel. The major changes involved installation of appropriate filters for the bioelectric signals and development of equipment interfaces.

Although most (an average of 56%) of the data obtained from the individual crew members during the last four replications was sufficiently artifact free to permit analysis, some problems in the collection of data remain to be remedied. The percentage of data scorable varied substantially across crew members from a low of 20% to a high of 95%. This variation was in part associated with crew member position, i.e., the mean percentage scorable for driver, gunner, tank commander, and loader positions was 62%, 56%, 38%, and 69%, respectively. The exceptionally low value for the tank commander may be associated with command responsibilities and/or having this position solely responsible for radio communication with personnel outside the tank. Generally speaking, the quality of the in-tank recordings were reduced by 1) radio-communication artifact which often obliterated recordings from all tank members, 2) movement artifact associated with the performance of required tasks, and 3) loss of subject-electrode connections which could not be corrected while the crew members were in the tanks.

The proportion of data scorable during recovery sleep was much greater with most subjects having 90% or more of their records scorable. The higher quality of the recovery sleep data relative to the tank data can be attributed to 1) the absence of radio communication artifact, 2) reduced movement artifact, and 3) the more favorable recording conditions of the recovery sleep environment.

In sum, EEG, EOG, and EMG recordings can be reliably obtained under the conditions associated with this experiment. It is recommended, however, that efforts be made to further increase the quality of recordings by 1) exploring ways to further minimize the artifact associated with radio communication and movement and 2) using back-up electrode sites to eliminate data loss associated with failed subject/electrode connections.

5.2.2 Recordings During the Vigil Periods

The data obtained indicate that psychophysiological recordings can be used during extended military operations to monitor alertness levels. As indicated above, a substantial proportion of the EEG, EOG, and EMG recordings were of sufficient resolution to permit scoring for wakefulness and different stages of sleep.

Sleep stage scoring revealed that 21%, 16%, 23%, and 22% of the artifact-free portion of the records was scored as sleep for the Driver, Gunner, Tank Commander, and Loader positions, respectively. It should be noted that these values may be overestimates of time spent asleep because artifact-free records were more likely in the absence of radio communication and movement. It should also be noted, however, that the data were scored in 30-s epochs which allows for brief (<15 s) lapses of wakefulness to go undetected. Whatever the exact values, it is apparent that the crew members were unable to maintain alertness continuously through out the vigil. In fact, as is evidenced by Table 5-1 which presents the time spent in the different stages of sleep for each crew member during each replication, some crew members actually attained stage 2 and even slow wave sleep.

During some replications, the crew members were given rest periods during which sleep was permitted. Two points can be made about these rest periods. First, they can not account for the majority of the sleep that was observed. That is, sleep was observed during replications with and without designated rest periods. Also, sleep did not tend to occur in consolidated blocks, rather it was highly fragmented and occurred in brief episodes throughout the vigil, especially after the first four or five hours. Secondly, the fact that sleep was not generally consolidated suggests that the crew members did not use the rest periods to reduce sleep debt. One explanation for the latter is that of the four crews for which there are scorable data, only one had a vigil period longer than 16 hours i.e., there was little sleep debt to be reduced. The frequent "napping" observed was almost certainly related to the boredom experienced during periods of inactivity. This may have been a particular problem for the drivers who had relatively little to do. An interesting possibility is that the sleepiness of the crew members was in part associated with the body heating effect occurring as a result of wearing the chemical defense ensembles.

TABLE 5-1 Time spent awake and in different stages of sleep during the vigil period. Values are presented for each crew member for each week of testing.

Week	Position	Vigil Time	% Scorable	% Awake	% Time in Stages 1	2	SWS	REM
1	Driver	17:02						
1	Gunner	17:02		NOT				
1	T/C	17:02		SCORABLE				
1	Loader	08:53						
2	Driver	21:15						
2	Gunner	21:15		NOT				
2	T/C	21:15		SCORABLE				
2	Loader	14:19						
3	Driver	11:19	41	60	18	9	12	0
3	Gunner	11:19	56	66	18	13	2	0
3	T/C	11:19	20	50	47	3	0	0
3	Loader	11:19	57	62	29	10	1	0
4	Driver	10:39	70	92	5	2	0	0
4	Gunner	15:27	45	76	14	10	0	0
4	T/C	15:27	26	77	6	8	7	0
4	Loader	15:27	59	86	7	6	0	0
5	Driver	27:33	93	85	9	5	2	0
5	Gunner	03:18	42	100	0	0	0	0
5	T/C	27:33	64	100	0	0	0	0
5	Loader	27:33	66	100	0	0	0	0
6	Driver	10:38	43	79	21	0	0	0
6	Gunner	04:19	79	92	8	0	0	0
6	T/C	10:38	43	79	21	0	0	0
6	Loader	10:38	95	64	36	0	0	0

NOTES 1 - "Vigil Time" is the time from entry into the tank until final exit

2 - "SWS" = Slow Wave Sleep; "REM" = Rapid Eye Movement Sleep

3 - "% Scorable" is percentage of the subject tapes that was scorable

4 - "T/C" = Tank Commander

5 - Position designation was based on position assignment at the beginning of the vigil; some crew members changed positions

5.2.3 Recordings During the Recovery Periods

The recordings obtained during the recovery sleep period were generally of high resolution and permitted sleep stage scoring of 90% or more of most of the crew members' records. The data from only three of the 20 subjects given recovery sleep were unscorable (due to a hardware problem associated with the SASSSY). Data from three additional subjects were lost from the tape on which it was stored.

Analysis of the data indicated that all of the subjects slept during most of the time permitted for recovery sleep. Sleep efficiency and the time spent in the different stages of sleep for each of the crew members during each replication is presented in Table 5-2. It can be seen that sleep efficiency was at or above 92% for all but one (84%) of the subjects for which there was scorable data.

Although inferential statistics could not be applied (because of the small number of observations and because of the nonindependence of observations within tank crews), much greater slow wave sleep and much less REM sleep was observed than would be expected during a normal sleep period. Study of the sleep staging data revealed that the crew members spent, on the average, 6%, 11%, 45%, 31%, and 6% in stage 0 (awake), stage 1, stage 2, stages 3 & 4 (slow wave sleep), and REM sleep, respectively. Study of the individual data in Table 5-2 shows considerable variation about these mean values. Eight of the 14 subjects had between 37% and 68% slow wave sleep and five of the 14 subjects had no REM sleep at all.

There are several possible explanations of the apparent increase in slow wave sleep and the apparent decrease in REM sleep. One possibility is related to the well known findings of elevated slow wave sleep and reduced REM sleep on the first night of recovery sleep following extended sleep deprivation. Sleep deprivation, however, could not be the sole explanation of the data here in that three out of the five crews for which there are data experienced little or no sleep deprivation because of the brevity of their vigil. Another possibility relates to the duration of the recovery sleep periods. That is, since slow wave sleep normally occurs during the first half of the normal 7 - 8 h sleep period, the proportion of time spent in slow wave sleep may have been unusually high because the subjects were permitted to sleep only about a third to a half (2 - 6 h) a normal sleep period i.e. the time during which slow wave sleep normally occurs. Finally, slow wave sleep and REM sleep are more likely to occur during certain times of the day. For example, placement of the brief recovery sleep period from 2400 to 0300 would result in substantial slow wave sleep and relatively little REM. These possibilities could not be statistically evaluated because of the small number of tank crews involved.

An additional possible explanation of the unusual slow wave and REM sleep is that it was due to body heating associated with the

Table 5-2 Time spent awake and in the different stages of sleep during the recovery sleep period. Values are presented for each crew member for each week of testing.

Week	Position	Record Time	% Scorable	% Awake	% Time in Stages 1	2	SWS	REM	SE
2	Driver	2:14	99	7	5	49	39	0	93
2	Gunner	2:14	85	6	14	59	5	3	94
2	T/C	2:14	84	1	11	48	48	0	99
2	Loader			NOT SCORABLE					
3	Driver	4:29	93	2	4	23	46	24	98
3	Gunner	4:56	81	3	21	38	37	2	97
3	T/C			NOT SCORABLE					
3	Loader	5:46	90	2	9	43	40	6	98
4	Driver	3:09	59	41	8	51	0	0	84
4	Gunner	4:29	97	3	9	58	29	0	97
4	T/C	4:48	92	2	25	57	9	12	98
4	Loader	6:33	96	4	3	64	21	5	96
5	Driver	4:07	97	1	6	49	40	4	99
5	Gunner			NOT SCORABLE					
5	T/C	4:07	96	8	9	37	37	8	92
5	Loader	4:07	93	7	16	44	20	13	93
6	Driver	5:19	31	2	11	20	68	0	98
6	Gunner			NO DATA					
6	T/C			NO DATA					
6	Loader			NO DATA					

NOTES 1 - "Record Time" is the time during which recording were obtained
2 - "SWS" = Slow Wave Sleep; "REM" = Rapid Eye Movement Sleep
3 - "SE" is Sleep Efficiency
4 - "T/C" = Tank Commander

chemical defense ensemble worn by the crew members while in the tank environment. The effect of heat on mood and performance has been of concern to military researchers (e.g., Grethier, 1973; Iampietro, et al., 1972) and has been studied in relation to the wearing of chemical defense ensembles (Hamilton, Simmons, & Kimble, 1982). Although recordings of core temperatures provided no evidence of body heating to the point that the subjects could be considered to be experiencing heat "stress" (temp > 39 degrees C.), the crew members were reported to perspire heavily and be uncomfortably warm while in the suits. Finally, body heating has been shown to increase slow wave sleep (e.g., Horne & Staff, 1983).

5.3 SUMMARY OF CONCLUSIONS

The data obtained lead to the following conclusions.

(1) Psychophysiological measures can be efficiently and reliably obtained during extended military operations of the type described in this report. Careful attention to electrode site preparation and use of backup sites minimizes data loss. Further effort is needed to explore ways to increase signal resolution and to minimize loss of data to artifact associated with radio communication and other sources of interference.

(2) Psychophysiological variables can be used to assess wakefullness and levels of sleep of personnel during extended military operations of the type described in this report. Analysis of the records obtained revealed that majority of the crew members participating in this study failed to continuously maintain alertness as called for by the experimental protocol. Episodes of sleep, sometimes deep sleep, occurred throughout the vigil period. The crew member's sleepiness may have been related to the body heating associated with wearing of the chemical defense ensembles. Increases in signal resolution and reduction in artifact are needed to permit assessing the value of using changes in the ongoing EEG to index levels of alertness during wakefulness.

(3) Examination of recovery sleep following extended operations may prove useful in assessing the consequences of extended operations and in evaluating changes in equipment and/or tasks. Although the sample size was not sufficient to statistically evaluate the data, unusual, if not abnormal, recovery sleep was observed. The possibility that the irregular sleep was associated with body heating occasioned by the wearing of a chemical defense ensemble suggests further studies.

6.0 REFERENCES

Grethier, W. F. (1973). Human performance at elevated environmental temperatures. Aerospace Medicine, 44, 747-755.

Hamilton, B. E., Simmons, R. R., & Kimball, K. A. (1982). Psychological effects of chemical defense ensemble imposed heat stress on army aviators. Ft. Rucker, Al: US Army Aeromedical Research Laboratory. USAARL Report No. 83-6.

Horne, J. A. & Staff, L. H. E. (1983). Exercise and sleep: Body heating effects. Sleep, 6, 36-46.

Iampietro, P. F., Chiles, W. D., Higgins, E. A., & Gibbons, H. L. (1969). High temperature and performance in a flight task simulator. Aerospace Medicine, 43, 1215-1218.

Rechtschaffen, A. & Kales, A. (Ed.s) (1968). A manual of Standardized Terminology, Techniques, and Scoring System for Sleep Stages of Human Subjects. NIH Publication No. 204, Washington, D. C. Government Printing Office.

DISTRIBUTION LIST

1 copy	Commander US Army Medical Researchand Development Command ATTN: SGRD-RMI-S Fort Detrick, Frederick, Maryland 21701-5012
2 copies	Defense Technical Information Center (DTIC) ATTN: DTIC-DDAC Cameron Station Alexandria, VA 22304-6145
1 copy	Dean School of Medicine Uniformed Services University of the Health Sciences 4301 Jones Bridge Road Bethesda, MD 20814-4799
1 copy	Commandant Academy of Health Sciences, US Army ATTN: AHS-CDM Fort Sam Houston, TX 78234-6100
1 copy	Commander U. S. Army Aeromedical Research Laboratory ATTN: Dr. Kent Kimball Fort Rucker, AL 36362-5000

END
4-87
DTIC