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TECHNOLOGY ASSESSMENT FOR THE ADVANCED LIFE DETECTOR

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This report summarizes an assessment of technology available to develop a noninvasive life detector for use on the battlefield. The detectors determine if casualties wearing chemical protective overgarments are alive or dead without further exposing either the casualties or the aidmen to the contaminated environment. Seven technology approaches sponsored by the Department of Defense (comprising 11 devices), four technologies identified in a market survey, and one device described in a Broad Agency Announcement proposal were examined as candidate Advanced Life Detectors. The technologies and instruments surveyed included three transmitter-receiver technologies, an electrocardiogram (ECG) technology, pacemaker-transmitter/receiver, dry electrode heart rate monitor, five microwave technologies, flash reflectance oximetry, an ultrasound technology, a streaming potential technology, a dry electrode ECG monitor coupled to a microphone, a stereometric technique for determining heart rate and blood pressure, and a vital signs monitor that determines heart rate and blood pressure using blood pressure cuff and (continued)

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19. microphones incorporated into the cuff.) Analysis of the state-of-the-art of each device indicates that none of them are advanced enough to fulfill all the requirements of the draft Joint Services Operational Requirement. Three of the devices identified are recommended for further evaluation.

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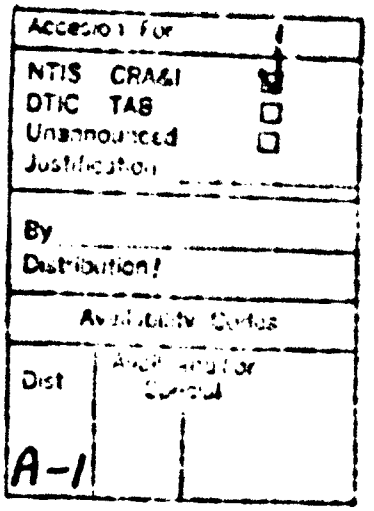

ABSTRACT

This report summarizes an assessment of technology available to develop a noninvasive life detector for use on the battlefield. The detectors determine if casualties wearing chemical protective overgarments are alive or dead without further exposing either the casualties or the aidmen to the contaminated environment. Seven technology approaches sponsored by the Department of Defense (comprising 11 devices), four technologies identified in a market survey, and one device described in a Broad Agency Announcement (BAA) proposal were examined as candidate Advanced Life Detectors (ALD). The technologies and instruments surveyed included three transmitter-receiver technologies, an electrocardiogram technology, pacemaker-transmitter/receiver, dry electrode heart rate monitor, five microwave technologies, flash reflectance oximetry, an ultrasound technology, a streaming potential technology, a dry electrode ECG monitor coupled to a microphone, a statometric technique for determining heart rate and blood pressure, and a vital signs monitor that determines heart rate and blood pressure using blood pressure cuff and microphones incorporated into the cuff. Analysis of the state-of-the-art of each device indicates that none of them are advanced enough to fulfill all the requirements of the draft Joint Services Operational Requirement (JSOR). Three of the devices identified are recommended for further evaluation.

INTRODUCTION

A Tri-Service Joint Working Group (TSJWG) on Advanced Life Detectors (ALDs) reviewed the status of five exploratory development efforts and outlined technical requirements for an ALD. The group agreed that a technology survey was needed to determine the potential for meeting requirements.[1] This survey included (1) review of the five ongoing developmental efforts, (2) review of other technologies, (3) a market survey of life detectors, and (4) a technology assessment plan (i.e., a test procedure) to select candidate(s) for engineering development.

MILITARY RATIONALE

Employment of chemical warfare agents on the modern battlefield by hostile forces has the capability of generating an unprecedented number of casualties, thus information is required to determine if casualties are alive or dead; this would enable the aidman to devote his limited time and resources to casualties who are salvageable.[2,3] The ALD is intended to assist in the selection of casualties for treatment and evacuation on the battlefield. The device must be usable when both the aidman and the casualty are wearing NBC protective ensembles and when the casualty is in chemical warfare agent protective patient wrap, without compromising protection.

METHODS

Technologies and instruments were evaluated on the basis of their conformance with or potential for meeting the requirements of the draft JSOR:[3]

a. The device will be capable of determining heart and respiratory rates.

b. Weight and volume shall be consistent with good engineering practices, and it is desired that dimensions not exceed 3in X 4in X 1/2in.

c. The display will be digital for heart and respiratory rates.

d. The display will be instantaneous.

e. The device will be operable in high noise and vibration environments.

f. The device will be capable of operating continuously for a minimum of 6 hours on its own power source.

The requirements for reliability, availability, maintainability, system safety, preplanned product improvement, manprint, etc. were not evaluated.

RESULTS OF REVIEW

The devices surveyed and the results of the evaluation are outlined below:

a. PERSONAL MONITOR AND COMMUNICATOR (PMC) SYSTEM (ARMY/TACKER). The ALD version of the PMC system is derived from an earlier device, developed at Purdue University Biomedical Engineering Center, that locates distant casualties by triangulation and interprets vital signs.[4] The PMC system is a two-unit device, one (wrist unit) to be worn by each combatant in the NBC theater under his protective clothing and the other (interrogator) to be carried by the aidman. The wrist unit resembles an over-size wristwatch; four dry electrodes in the wristband detect tissue volume changes by impedance measurements. The unit basically measures pulse, but other vital signs, such as respiratory rate, can be derived in principle. As presently configured, the wrist unit transmits pulse to the aidman's interrogator using a 440.6 MHz signal. The ALD version, which is presently being developed at Purdue, will have a much shorter range, probably no more than a few feet. The aidman's unit (i.e., the receiver) was not completed at the time of inspection (August 1987); it was simulated on a personal computer. The pulse signal appeared to be picked up satisfactorily during normal arm movements, and it is claimed that the system functions while the wearer is jogging.[4] The present contract covers development of the ALD interrogator and miniaturization of the wrist unit.

Prognosis: The present contract calls for delivery of the prototype ALD version of the PMC on 1 September 1988. This schedule should be met, but the precise configuration of the unit is uncertain. The device should satisfy the requirements of the draft JSOR, although it is not certain at this time that the wrist unit can be made small enough to be practical for issue to all combatants.

b. MICROWAVE SYSTEM (NAVY/SIEGEL). A heart and respiratory rate monitor has been developed under Navy contract by the Michigan State University Electrical Engineering and Systems Science Division. The demonstration unit was observed in August 1987. It is a single box about twice the size of a hand calculator and employs a 10 GHz microwave source with a pulsed doppler detector and digital readout. It is designed to operate at 1-2 feet or less from the subject. Even though the highly sophisticated algorithms of speech processing are used, normal variability in heart rate complicates separation of the heart rate signal from extraneous vibrations.[5] The first-generation device was demonstrated by means of a mechanical heart simulator rather than a live subject; both detector and heart simulator were firmly anchored on a bench. The second-generation device, which uses more advanced signal processing, will discriminate more effectively; but the fielded device in all probability will still need rigid support to provide stability.[5]

Prognosis: It is understood that sufficient funding exists to complete the second-generation device[6] which could be ready for evaluation by the summer of 1988.[5] It is unlikely that the first-generation device can satisfy the JSOR with respect to noise and vibration, although other requirements should be met.

c. MICROWAVE SYSTEM (AIR FORCE/SEALS). A heart and respiratory rate monitor has been developed under Air Force contract by the Georgia Technical Research Institute Biomedical Research Division.[7] A preprototype (brassboard) device was observed in operation at Brooks Air Force Base during August 1987 and discussed with the contractor. The device, roughly the size and appearance of an old-fashioned wall telephone, was developed in both 3 GHz and 10 GHz versions and is capable of remote detection up to about 10 meters. It is described as a dual-channel microwave phase detector. The microwave generation and detection are more sophisticated than those of the Navy/Siegel system, but it lacks the latter's advanced digital signal processing; in fact, the signal is presented on an oscilloscope, which is useful for diagnostic information, but not suitable as a life detector. (The device is intended as a vital signs monitor.) As with other microwave systems, a steady platform is required; but this requirement may be eliminated with better signal processing.[8] No further development is projected at this time.

Prognosis: Since it lacks a suitable display for life signs and is unable to satisfy the noise and vibration requirement, this device is not a candidate for comparative evaluation as an ALD within the requirements of the JSOR.

d. MICROWAVE SYSTEM (NAVY/SEALS). A heart and respiratory rate monitor with distant sensing capability has been developed under Navy contract by Georgia Technical Research Institute Biomedical Research Division. This device, similar in function to the one above developed for the Air Force, is designed to detect vital signs at distances of 100 meters and is intended to permit life detection without risk to the aidman. At this time, readout is by oscilloscope. It requires a very steady platform and an optical sight. The device exhibits the shortcomings of all microwave systems in its inability to discriminate between life signs and strong returns in the same frequency range; a recent report from the contractor suggests that distant microwave detectors are not practical for outdoor use.[9] The brassboard device inspected during August 1987[6] was not in operation. No further development is projected at this time.

Prognosis: Lacking a suitable life signs display, with inability to satisfy the noise and vibration requirement and perhaps inability to meet the size limitation as well, this device is not a candidate for comparative evaluation as an ALD within the requirements of the JSOR.

e. MICROWAVE SYSTEM (NAVY/CHEN). A heart and respiration rate detector with remote/distant capability has been developed under Navy contract by the Michigan State University Department of Electrical Engineering and Systems Science.[10] This system, capable of detecting life signs behind a concrete block wall at a distance of 3 meters, was conceived as a means for locating victims buried in rubble. Signal presentation is by oscilloscope.[6] The device has not been fully developed and was not inspected.

Prognosis: A suitable device is not available for comparative evaluation.

f. MICROWAVE SYSTEM (ARMY/NOWOGRODZKI). A noncontact heart rate monitor was developed by RCA Corporation under Army contract.[11] A prototype device was delivered, but it was "extremely sensitive to slight sensor movements which produce frequent erroneous readings."[12] Further development was not undertaken.

Prognosis: A suitable device is not available for comparative evaluation.

g. ULTRASONIC SYSTEM (ARMY/CHANG). A noncontact heart rate monitor was developed by IBS Corporation under Army contract. The device is an ultrasonic transceiver which is based on the Doppler effect to detect movement of the heart wall or aortic blood flow.[13] Ultrasonic systems usually use a gel/skin contact since ultrasound is strongly attenuated by air, even the small amount of air in a layer of clothing;[14] but it is claimed that heart rate could be measured with the subject wearing normal clothing, as well as a protective garment.[13] A prototype was delivered, but it was "extremely sensitive to motion."[12] Further development was not undertaken.

Prognosis: A suitable device is not available for comparative evaluation.

h. STREAMING POTENTIAL (ARMY/SHAFER). A noncontact heart rate monitor was developed by Titan Systems Incorporated under Army contract. This device is based on the disputed concept that a field, the "streaming potential," is generated by the body when blood is forced through the capillaries.[14,15] A prototype was delivered, but "the sensor only works when used on a brachial or carotid artery and is extremely location sensitive."[12] Further development was not undertaken.

Prognosis: A suitable device is not available for comparative evaluation.

i. VITAL SIGNS DETECTOR (AIR FORCE/LESSARD). Two devices for detecting heart and respiratory rate of casualties in protective garments have been developed by Texas A&M University under Air Force contract. Both brassboard devices were inspected at Brooks Air Force Base in August 1987. Both are noninvasive, but both require direct skin contact; the hood of the NBC protective mask would have to be raised to provide access to the throat area. In both, sensors and digital indicators are separate units. The more successful one has a yoke-shaped sensor that fits the throat of the casualty, with four electrocardiogram dry electrodes mounted on the sensor arms of the yoke to detect heart beat and a centrally-mounted microphone for respiration rate. This device gave a reasonably good heart rate indication when tested on a human subject; the readout was voice stable, but not very stable to mechanical vibration. Readout of respiration rate was less satisfactory. The second device (roughly, a 6-inch tube) uses a single microphone probe to pick up heart and respiratory sounds; neither indication was usable. Both devices are reported to have worked well at the breadboard stage with an oscilloscope as detector.[16]

Prognosis: Neither device meets JSOR criteria for an ALD for NBC battlefields so long as direct skin contact is required. While it is conceivable that either device could be given noncontact or remote capability (similar to the PMC), no such development is contemplated.

j. VITAL SIGNS MONITOR (ARMY/SAMARAS). A noncontact vital signs monitor has been developed in prototype by GMS Engineering Corporation under Army contract. This device uses an arm cuff to pick up heart rate and blood pressure, and an anemometric transducer to measure respiratory rates and volumes. The device can be used with the casualty in the chemical protective ensemble or protective patient wrap. It is functional in high noise and vibration environments, such as the M113 armored personnel carrier. This is a diagnostic instrument, and not an ALD as such; it was evaluated to determine whether it could meet requirements as an ALD.

Prognosis: The device is too large and heavy to meet the size and weight requirement, and the cuff is too cumbersome to permit rapid indication of life signs on a battlefield.

k. VITAL SIGNS MONITOR (ARMY, AIR FORCE/ALLING). A noncontact vital signs monitor has been developed in prototype by Arthur D. Little, Inc., under joint Army and Air Force funding. The device was not inspected, but it is understood to be similar in function and capabilities to the device described immediately above.[17] A competitive comparison of the two units was scheduled by the Air Force for October 1987.[18]

Prognosis: It appears that this device will be too large, heavy, and cumbersome to meet the requirements of an ALD.

l. FLASH REFLECTANCE OXIMETER (SAMARAS). A device described in a BAA proposal from GMS Engineering Corporation is based on oximetry, a technique for determining arterial hemoglobin oxygen saturation. An alive-or-dead indication is given in less than one second, and the device is not motion-sensitive. Because an oximeter measures integrated cardiopulmonary function, it indirectly meets the requirement for heart and respiration rate. In its present configuration, it indicates the absence of heart beat as well as hemoglobin saturation; the offeror states that it could be readily reconfigured to provide a heart rate indication in less than 10 seconds. The projected size and weight of the prototype are 27 in^3 and 1.5 lb., respectively.

Prognosis: No suitable device exists for evaluation; however, this is the only system of which we are aware that meets the basic requirement for a small device that provides a rapid, reliable, alive-or-dead indication without support equipment attached to the casualty.

MARKET SURVEY RESULTS

A market survey was conducted, and six approaches representing four developmental units (two already described above) and two nondevelopmental units were identified.[19]

a. Nondevelopmental Systems:

(1) BIOSIG INSTRUMENTS, INC. The system is similar in function to the PMC under development at Purdue. A miniature transmitter is mounted on an elasticized chest belt containing ECG electrodes. The heart-rate signal is transmitted to a wrist unit or other small receiver; each transmitter has a discrete frequency (up to 80 channels). The manufacturer claims that the system can be used to monitor the pulse of athletes which may relate to the suitability and reliability of the system in the field.

Prognosis: The device apparently qualifies for technology assessment.

(2) BUFFINGTON CLINICAL SYSTEMS. The Buffington cuff system is more nearly a vital signs monitor than advanced life detector. It resembles an ordinary blood pressure cuff, but the output is a pressure change related to pulse volume; when connected to a MicroCor ECG monitor, it provides a digital display of pulse rate and a wave display of pulse amplitude. It is claimed that the cuff will function through several layers of heavy clothing, although it would certainly be unsuitable for use with the protective patient wrap. The monitor is the size of a pocket calculator.

Prognosis: Additional information is required to assess this system. The principal question concerns the time needed to get a life sign indication. In its present configuration, the device fails to meet the requirement to provide a life sign indication through the protective patient wrap.

b. Developmental Systems:

(1) MEDICAL MONITORING SYSTEMS, INC. (MMS). This device represents another variation on the detector-transmitter-receiver system exemplified by the PMC. A BAA preproposal was submitted earlier this year by MMS and reviewed by USABRDL. The preproposal is technically inadequate; until detailed information is provided, evaluation of the suitability of the device is not possible.

Prognosis: No suitable device exists for evaluation.

(2) THOUGHT TECHNOLOGY LTD. This device is claimed to be a passive heart rate and temperature monitor based on pacemaker technology. The passive sensor (undefined) attaches to the chest with a stick-on strip and is electrically activated when the monitor is placed over the chest. Apparently, a prototype of sorts exists; it is claimed to meet size limitations but may have problems relating to motion and noise.

Prognosis: Although a thorough evaluation of this system is not possible at this time, the concept and approach appear promising.

Compliance with critical requirements is summarized in Table 1 for all devices surveyed.

DISCUSSION

Methods for life signs detection have been reviewed by Lessard and Wong[14] and are represented by the devices inspected. Most of them are based on traditional measurements, such as heart rate, respiration rate, pulse, and blood pressure. Innovative concepts, such as oximetry, are only beginning to reach the research and development stage. After reviewing the current systems designed to detect vital signs, it is apparent that few if any of them are sufficiently advanced to fulfill the requirements of the JSOR, and the development of a test plan for the proposed tri-service evaluation of devices is premature. However, the following check list is proposed as a guide:

a. Vital Sign. The vital sign employed must be (within reason) a reliable life/death indicator and should not be limited to traditional measurements of heart and respiratory rates.

b. Weight and Size. The limitation of 3in. x 4in. by 1/2 in. is probably unattainable in a single unit at this time. The developer should strive for a device not exceeding approximately 20 in^3 and 1 lb. in the final configuration.

c. Display. Whether digital or analog, the data should be displayed in terms of the life sign indicated, for example a digital heart rate indicator, or a go/no-go display.

d. Speed. A life/death indication should be made within 30 seconds with both casualty and aidman in NBC protective ensembles. (An instantaneous indication is highly unlikely, especially if the parameters measured are heart and respiratory rates.)

e. Noise and Vibration. The level of noise, vibration, or other movement the device will encounter is a matter dictated by where the device is used; however, as a minimum, it is suggested that the device must give reliable, repeatable life sign indications when hand-held by the aidman.

f. Battery Life. The device should function for at least 6 hours on an integral power source, based on a 30-second requirement for each alive-or-dead measurement. (Battery life is probably an inappropriate requirement since there will be large variations in power draw for different devices; it would be better to specify the number of measurements per recharge.)

TABLE 1. SUMMARY OF CANDIDATES EVALUATED[a]

Candidate	REQUIREMENT					
	NBC[b]	Vital sign[c]	Weight & size[d]	Presentation[e]	Speed[f]	Noise & vibr[g]
PMC	+	+	?	+	+	+
Microwave						
USN/Siegel	+	+	+	+	+	?
USN/Seals	+	+	-	-	+	-
USAF/Seals	+	+	-	-	+	-
USN/Chen	+	+	#	-	+	#
USA/RCA	+	+	+	+	+	-
Ultrasound	+	+	+	+	+	-
Streaming Pot.	+	+	+	+	+	-
Yoke Probe (USAF)	-	+	+	+	+	?
Tube Probe (USAF)	-	-	+	+	+	?
VSM/GMS	+	+	-	+	?	+
VSM/ADL	+	+	#	#	#	#
Biosig ECG	+	+	+	+	+	?
Buffington Cuff	-	+	+	+	?	?
MMS Device	?	+	?	?	?	?
Thought Technol.	+	+	?	?	?	?
Oximeter/GMS	+	+	+	+	+	+

a. +: The device meets the requirement or can reasonably be expected to do so after normal development.

-: The device fails.

?: Success is uncertain.

#: Neither the device nor data sheets have been examined.

b. The device can be used with both aidman and casualty in protective ensembles or with the casualty in protective patient wrap without compromising NBC protection.

c. The vital sign is heart rate and/or some other suitable parameter.

d. Weight and size can be expected not to exceed approximately 1 lb. and 20 in^3 in final configuration.

e. The presentation is digital or analog. (Conversion from an oscilloscope readout is not considered "normal development.")

f. A life sign indication is presented in 30 seconds or less.

g. A reproducible life sign is possible with both aidman and casualty undergoing moderate movement.

CONCLUSIONS AND RECOMMENDATIONS

1. At this time there are three completed or nearly completed devices known to USABRDL that might serve as life detectors within the scope of the draft JSOR. These are the PMC, under development at Purdue University; the second-generation microwave system, under development at Michigan State University; and the Biosig ECG device, which is a commercial item. The earliest date for testing developmental items will be September 1988.

2. In consideration of the above, it is recommended that the three systems described be considered for evaluation according to the proposed test plan in October 1988.

3. The Joint Services should continue to seek more satisfactory solutions.

a. Development of the flash reflectance oximeter, such as that proposed by GMS Engineering Corporation, should be pursued vigorously.

b. The Buffington Clinical Systems cuff should be evaluated.

c. A demonstration of the principle underlying the Thought Technology LTD heart rate and temperature monitor should be sought.

REFERENCES

(1) Memorandum, SGRD-UMA, 20 May 87, subject: Minutes for Tri-Service Joint Working Group (TSJWG) on Advanced Life Detector.

(2) Letter, HSHA-CDM, 21 Jan 83, subject: Letter of Agreement (LOA) for an NBC Casualty Noninvasive (Heart Rate) Survival Monitor.

(3) Memorandum, HSHA-CDM, 27 Jul 87, subject: Draft Joint Services Operational Requirement (JSOR) for the Advanced Life Detector (ALD).

(4) Tacker, W.A., Jr., J.T. Jones and K.S. Foster. 1986. The Personal Monitor and Communicator. Final Report, DAMD17-85-G-5012. U.S. Army Medical Research and Development Command, Ft. Detrick, Frederick, MD.

(5) Dr. Marvin Siegel, Michigan State University, personal communication, August 1987.

(6) Cdr R. Wolf, USN, personal communication, July 1987.

(7) Seals, J., S.R. Crowgey and S.M. Sharpe. 1986. Electromagnetic Vital Signs Monitor. Final Report, Air Force Contract No. F33615-83-D-0601. USAF School of Aerospace Medicine, Brooks AFB, TX.

(8) Dr. David N. Erwin, USAF School of Aerospace Medicine, personal communication, August 1987.

(9) Pacela, A.F., ed. 1987. Microwave Beam Monitors Burn Victims' Vital Signs. Biomed. Technol., 14(15), 170.

(10) Chen, K-M., D. Misra, H. Wang, H-R. Chuang and E. Postow. 1986. An X-Band Microwave Life-Detection System. Trans. Biomed. Eng., BME-33 (7), 697-701.

(11) Mawhinney, D.D. 1983. Noninvasive Heart Rate Monitor. Final Report, Phase I, DAMD17-83-C-3018. U.S. Army Medical Research and Development Command, Ft. Detrick, Frederick, MD.

(12) Memorandum, SGRD-UBE-E, 27 Dec 1984, subject: Meeting with Contractors for Heart Rate and Vital Signs Monitors.

(13) Chang, K.W. and S.Y. Chang. 1983. Noninvasive Heart Rate Monitor. Final Report, Phase I, DAMD17-83-C-3019. U.S. Army Medical Research and Development Command, Ft. Detrick, Frederick, MD.

(14) Leasard, C.S. and W.C. Wong. 1984. Evaluation of Noninvasive Measurement Methods and Systems for Application in Vital Signs Detection: Part 1. Literature Review. USAFSAM-TR-85-44-Pt-1. USAF School of Aerospace Medicine, Brooks Air Force Base, TX.

(15) Decision Science, Inc. 1984. Proposal for Evaluating the Heart Rate Monitor Sensor as a Vital Signs Monitor. Titan Systems, Inc. La Jolla, CA.

(16) 1LT William Randolph, USAF School of Aerospace Medicine, personal communication, August 1987.

(17) Gordon Alling, Arthur D. Little, Inc., personal communication, September 1987.

(18) CPT William Marley, USAF School of Aerospace Medicine, personal communication, August 1987.

(19) EER Systems. 1987. Market Survey Investigation for Advanced Life Detectors. Draft final report, Contract No. DAMD17-84-C4261, Task Order No. 4A02-A-7-2095, U.S. Army Medical Research and Development Command, Ft. Detrick, Frederick, MD.

APPENDIX A

DEFINITIONS

An advanced life detector (ALD) is a device to be used by an aidman to determine if a battlefield casualty is alive or dead. For the purpose of this report, noninvasive means that the device does not penetrate the skin (although radiation from the device may); noncontact means that the device can measure through heavy clothing; remote means that the device need not touch the body at all; and distant means that the device can operate at distances of 10 meters or more.

APPENDIX B

GLOSSARY

ALD	Advanced Life Detector
BAA	Broad Agency Announcement
ECG	Electrocardiogram
JSOR	Joint Services Operational Requirement
NBC	Nuclear, Biological and Chemical
PMC	Personal Monitor and Communicator
TSJWG	Tri-Service Joint Working Group
USA	U.S. Army
USABRDL	U.S. Army Biomedical Research and Development Laboratory
USAF	U.S. Air Force
USN	U.S. Navy
VSM	Vital Signs Monitor

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