JOINT CHEMICAL AGENT DETECTOR (JCAD)

THE FUTURE OF CHEMICAL AGENT DETECTION (U)

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ABSTRACT (U)

(U) The Joint Chemical Agent Detector (JCAD) will provide state of the art chemical warfare agent detection capability to ground vehicle operators. Intelligence sources estimate that over twenty countries have active chemical weapons programs. The spread of chemical weapons (and the industrial capability for manufacture) to third world nations, coupled with the potential for U.S. involvement in these areas in an operational or support capacity, increases the probability that the Joint Services may encounter chemical agents and toxic industrial materials anywhere in the world. Currently, fielded chemical agent detectors are bulky, labor intensive, and subject to false readings. No legacy detector is sensitive enough to provide detection and warning of the low dose hazards associated with miosis contamination.

(U) The JCAD will provide a small (40 in^3), lightweight (2 lb.) chemical agent detector for vehicle interiors, aircraft, individual personnel, shipboard, and fixed site locations. The system provides a common detection component across multi-service platforms. This common detector system will allow the Joint Services to use the same operational and support concept for more efficient utilization of resources. The JCAD will detect, identify, quantify, and warn of the presence of chemical agents prior to onset of miosis. Upon detection of chemical agents, the detector will provide local and remote audible and visual alarms to the operators. Advance warning will provide the vehicle crew with the time necessary to protect themselves from the lethal effects of chemical agents. The JCAD will also be capable of being upgraded to protect against future chemical agent threats. The JCAD will provide the vehicle operators with the warning necessary to survive and fight in a chemical warfare agent threat environment.

1. (U) Threat

(U) Intelligence sources estimate that over twenty countries have active chemical weapons (CW) programs. Although signatories to various conventions banning nuclear, biological, and chemical (NBC) warfare, several third world countries continue to develop, test, and evaluate chemical warfare agents, and the means to disseminate them. Some are developing new agents which challenge the U.S. detection, protection, and treatment capabilities. Chemical warfare agents may be delivered by standard weapon systems or by special operations forces. Toxic agent clouds form when chemical weapons or devices function and again when the agent deposited on the surface begins to evaporate. Such agent clouds are airborne and can maintain their form and hazardous agent concentrations for significant distances. In variable winds, these clouds may repeatedly traverse the same area. The spread of these weapons (and the industrial capability for manufacture) to third world nations, coupled with the potential for U.S. involvement in these areas in an operational or support capacity, increase the probability that Joint Forces may encounter CW and/or toxic industrial material (TIM) anywhere in the world. Insurgent, criminal, and terrorist groups can acquire or produce chemical agents and can use them for military, political or criminal purposes. Blister and nerve agents can be disseminated with non-standard devices, such as agricultural sprayers or other field expedient devices. The nerve agent attacks conducted in Japan in 1994 and 1995 clearly demonstrated the potential of this threat. Several thousand new chemicals are synthesized annually. Any one of these new materials may be toxic and have the potential to be weaponized.

(U) Currently fielded chemical agent detectors are bulky, labor intensive, and subject to false readings. No legacy detector is sensitive enough to provide detection and warning of the low dose hazards associated with miosis contamination. All Services conduct liquid detection using M-8 paper or M-9 tape, and vapor detection using the M8A1 or M-256A1 kits. The Chemical Agent Monitor (CAM) is used for CW agent survey missions. In addition, there is currently no portable device available that operates effectively in the shipboard environment. The extreme levels of electromagnetic interference (EMI) exterior to the ship and the high and continuous levels of organic vapors (aqueous film-forming foam (AFFF), cleaners, floor waxes, paints, fuels, etc.) in the ship’s interior render existing devices useless. The Operational Requirements Document (ORD) for the Joint Chemical Agent Detector (JCAD), 1 July 1997, establishes the need and requirements by the joint services for a new, state of the art chemical agent detector.

2. (U) Joint Chemical Agent Detector (JCAD)

2.1. (U) Mission

(U) The JCAD is capable of supporting the mission requirements of all four services. These include:

- Interior detection for both tracked and wheeled-vehicles
- Fixed- and rotary-wing aircraft interior detection during both ground and airborne operations
- Shipboard interior and exterior detection
- Fixed site chemical agent detection
- Personal detector to be carried on a individual soldier or used for advanced warning
- Chemical agent surveys of personnel, equipment, and cargo

(U) The JCAD will provide Army and Marine Corps units with personal detectors, fixed installation detectors, and chemical survey detectors for chemical vapor hazards. Early detection and warning for CW agents will allow the forces to take, maintain or change the Mission Oriented Protective Posture (MOPP), thus increasing combat effectiveness. The JCAD personal detectors and vehicle mounted detectors will monitor the chemical vapor concentration and accumulated dosage. The JCAD may be employed under all typical battlefield conditions expected during high, medium, and low intensity conflicts when employment of chemical weapons or exposure to toxic industrial material is likely. The JCAD will be used in route reconnaissance, area/zone reconnaissance, and surveillance missions for contamination avoidance. In the surveillance mission, the JCAD will monitor contamination levels of personnel, equipment, and cargo.

(U) The JCAD will provide the Air Force (AF) with aircraft interior detectors, fixed installation detectors, and chemical survey detectors. The AF will use the JCAD on fixed- and rotary wing-aircraft during flight operations. The detector will operate concurrently with aircraft ground servicing tasks to include, but not limited to aircraft refueling, loading and off-loading cargo, routine maintenance, preflight and post-flight inspections, and fleet servicing equipment or materials.

(U) The JCAD will provide the Navy with a portable, post attack monitor for use by chemical survey teams. The JCAD will also be used as a stationary detector for designated interior spaces of ships, landing craft, aircraft, and vehicles. The detector will be used to identify contaminated spaces and to determine the spread of contamination.

2.2. (U) Technical Features

(U) The heart of the JCAD is the detector unit shown in Figure 1.

Figure 1. (U) JCAD Detector Unit

(U) The detector unit simultaneously detects nerve (Sarin (GA), GB, Soman (GD), GF, and VX), blister (Mustard (H), Nitrogen Mustard (HN3), and Lewisite (L)), and blood (Hydrogen Cyanide (AC) and Cyanogen Chloride (CK)) CW agents. The required detection sensitivities are listed in Table 1. The detector unit weighs two pounds and is 40 cubic inches (4 in. wide by 7 in. tall by 1.5 in. deep) in volume. The unit is capable of worldwide operations from -32 to 49^{o}C and in any environment. The JCAD detector unit will operate on either platform power or an internal battery. The unit will use the BA-5800 battery which is the same one used in the Rockwell PLGR. The battery life is expected to be greater than 18 hours on the primary battery or approximately 12 hours on a rechargeable being provided by the JCAD prime contractor.

Agent	Threshold Exposure Concentration (mg/m^3) @	Threshold Exposure Response Time Max (sec) @	Relative Humidity (%RH) Range	Temperature Range (°C)
VX	1 0.1 0.04 0.001*	≤10 ≤30 ≤90 ≤1800	5 to 100	+9 to +49 at 1 mg/m^3 -6 to +49 at 0.1 mg/m^3 and 0.04 mg/m^3
GA, GB, GD & GF	1 0.1 0.001*	≤10 ≤30 ≤1800	5 to 100	-28 to +49
HD	50 2 0.02*	≤10 ≤120 ≤1800	5 to 100	-5 to +49 at 50 mg/m^3 -18 to +49 at 2 mg/m^3
L	50 2 0.02*	≤10 ≤120 ≤1800	5 to 100	-14 to +49
HN3	50 2 0.02*	≤10 ≤120 ≤1800	5 to 100	+16 to +49
AC	2500 22	≤10 ≤60	5 to 100	-32 to +49
CK	20	≤60	5 to 100	-32 to +49

*Maximum alert response time at low concentrations. Uses a pre-concentrator.

Table 1. (U) JCAD Detection Requirements

(U) The JCAD uses surface acoustic wave (SAW) technology to detect the chemical warfare agents. The SAW sensor is a small, piezoelectric quartz crystal that is coated with a proprietary polymer. The SAW crystals are part of a high performance oscillator circuit and eight SAW crystals form the chemical sensor array in the detector unit. The base frequencies for the SAWs are 275 MHz. Each polymer is specifically designed to attract nerve, blister, or blood CW agents. The CW agents are selectively adsorbed by the polymer, thus changing the resonant frequency of the SAWs. The frequency changes from the SAW array are processed by a neural network algorithm to determine the type

and concentration of the chemical agent. The neural network algorithm can also be upgraded as new threat agents are identified.

Figure 2: (U) JCAD Detector Unit with Pre-Concentrator Attached

(U) The low level detection requirements are accomplished with the use of a pre-concentrator (PC). Figure 2 shows the detector unit with the PC attached. The PC is a quick release, peripheral attachment that uses an adsorbent to collect low level chemical agents for 20 minutes. During the collection period, the detector unit continues to sample the ambient air for "high" chemical agent concentrations that require an immediate response. At the completion of the collection period, the PC pump is reversed and the adsorbent ballistically heated to release the chemical agent vapors. The vapor "slug" is drawn through detector unit for agent detection and identification. The PC will meet the same temperature and environmental conditions as the basic detector unit. The size of the PC is 4 in. wide by 2 in. tall by 1.5 in. deep.

(U) The detector unit and PC interface with the various Service platforms is accomplished via the JCAD universal mount. The universal mount with detector attached is shown in Figure 3. The universal mount acts as a cradle for the JCAD detector unit and provides physical, electrical, and communications interfaces with the host platform. The universal mount provides power conversion from the host platform

prior to the detector unit. External power capability is 12 to 28 volts DC and 110 to 240 volts AC, 50 to 60 Hz, single phase. A RS-232 communications port is provided, as well as, push pins for interfacing with WD-1 field wire. The program objective is to provide a JCAD and universal mount that does not require any platform specific interfaces.

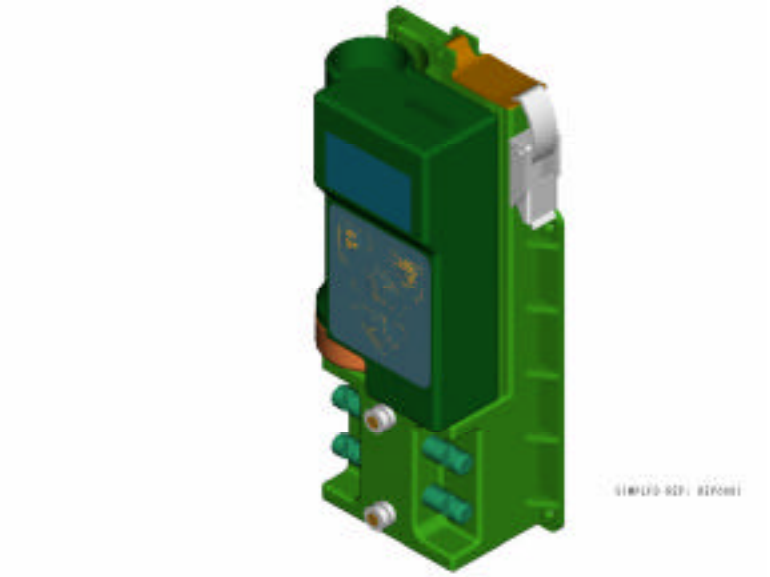

Figure 3: (U) JCAD Universal Mount with Detector Unit Attached

2.3. (U) Operational Features

(U) The JCAD detector unit will provide immediate operator feedback in the event of chemical agent detection. The operator will be notified via the liquid crystal display (LCD), light emitting diode (LED), and an audible signal. Figures 4 and 5 show the LCD display with a single chemical agent challenge screen and a multiple agent challenge screen, respectively. The LCD is night vision system compatible and all of the operator alert functions may be adjusted to match the desired mission requirements. The JCAD will also interface with the Joint Warning and Reporting Network (JWARN). The chemical attack information provided to the JWARN will support the preparation of ATP-45 reports. The JWARN interface will allow the JCAD to be used as a networked fixed site detector without direct operator contact. A hasty, perimeter network (Deployable Detector Unit Network (DDUN) function) may be employed through the use of personal detector units and WD-1 field wire. Up to 10 JCADs may be “strung” together at distances up to 400 meters apart. The base unit functions as a control unit to provide chemical alerts and malfunction signals for the other 9 units that are deployed.

3. (U) Acquisition Team

(U) The JCAD engineering and manufacturing development (EMD) is scheduled for the critical design review (CDR) in April 00. The program is led by the Air Force 311th Human Systems Wing at Brooks AFB, TX. The program is supported by the Army

Figure 4: (U) Single Chemical Agent Challenge Screen

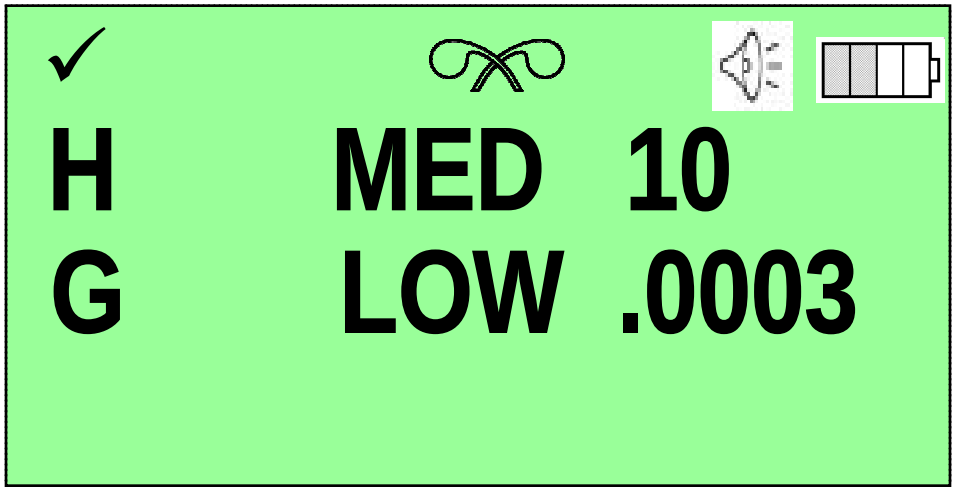

Figure 5: (U) Multiple Chemical Agent Challenge Screen

Program Manager for Nuclear, Biological, and Chemical (PM-NBC); the Marine Corps System Command (MARCORSYSCOM), and the Naval Sea Systems Command (NAVSEA). The prime contractor for the JCAD is BAE Systems in Austin, TX.

(U) Prototype chemical agent testing of the SAW sensor array is currently being conducted at Edgewood Chemical and Biological Center (ECBC) and West Desert Test Center (WDTC). Initial engineering test and evaluation (ET&E) is scheduled for July 2000, followed by Developmental Test and Evaluation in September 2000. The current military requirement for the JCAD is 257,135 units broken down as follows:

- US Army - 230,000
- US Marine Corps - 15,485
- US Air Force - 9,150
- US Navy - 2,500

Production award for the JCAD is scheduled for February 2002 and initial operational capability, November 2002.

4. (U) Summary

(U) The Joint Chemical Agent Detector (JCAD) will provide all of the military services with a common tool for the detection, identification, and quantification of chemical warfare agents and some toxic industrial material. The JCAD is a two lb., 40 in3, chemical warfare agent detector that can be employed on ground vehicles, aircraft, ships, and as a personal detector. The improved detection sensitivity will provide the user with hazard alerts prior to the on-set of miosis. This advanced warning will give personnel the time necessary to protect themselves from the lethal effects of chemical agents and allow U.S. forces to survive and fight in a contaminated environment.