DEPARTMENT OF DEFENSE

MILITARILY CRITICAL TECHNOLOGIES LIST

SECTION 5: CHEMICAL TECHNOLOGY

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PREFACE

The Militarily Critical Technologies List (MCTL) Program provides a systematic, ongoing assessment and analysis of goods and technologies to identify those that are critical to the Department of Defense (DoD). It characterizes the technologies (including quantitative values and parameters) and assesses worldwide technology capabilities.

The MCTL is a compendium of goods and technologies that DoD assesses would permit significant advances in the development, production, and use of the military capabilities of potential adversaries. It includes goods and technologies that enable the development, production, and employment of weapons of mass destruction (WMD). Goods and technologies are considered critical if their acquisition and exploitation by a potential adversary would either significantly negate or impair a major military capability of the United States or significantly advance a critical military capability of the adversary. A leading edge technology that has a high potential for advanced military application can be included even if it is not currently embedded in a U.S. system.

Technologies are identified through the deliberation and consensus of Technology Working Groups (TWGs) whose members are subject matter experts from government, industry, and academia. TWG chairpersons continually screen technologies and nominate items to be added or removed from the MCTL. Working within an informal structure, the TWGs strive to produce precise and objective analyses across the technology areas and to update these assessments periodically.

The legal basis of the MCTL stems from the Export Administration Act (EAA) of 1979, which assigned responsibilities for export controls to protect technologies and weapons systems. It established the requirement for DoD to compile a list of militarily critical technologies. The EAA and its provisions, as amended, have been extended by Presidential Directives.

The MCTL is not an export control list. Items on the MCTL may not be on an export control list, and items on an export control list may not be on the MCTL. The MCTL is designed to be used as a reference for evaluating potential technology transfers and for reviewing technical reports and scientific papers for public release. Technical judgment must be used when applying the information. The MCTL should be used to determine whether the proposed transaction would result in a transfer that would give potential adversaries access to technologies whose specific performance levels are at or above the characteristics identified as militarily critical. It should be used with other information to determine whether a transfer should or should not be approved.

An Index of MTCL Technology Data Sheets is provided with each MCTL section. Separate documents contain a Glossary and a list of Acronyms and Abbreviations.

This document, MCTL Section 5: Chemical Technology, supersedes the chemical portion of MCTL Part I, Section 3: Chemical and Biological Systems Technology, June 1996.

SECTION 5—CHEMICAL TECHNOLOGY

Scope

Highlights

- LORAN remains an option to disseminate accurate time and determine position for critical redundancy. The objective of the Department of Defense (DoD) Chemical and Biological Defense Program (CBDP) is to enable our forces to survive, fight, and win on a chemically and/or biologically contaminated battlefield.
- The cornerstone of U.S. chemical and biological defense efforts is early detection and warning to provide situational awareness and allow U.S. forces to avoid the threat if possible.
- If employed properly, obscurants can negate the value of high-technology reconnaissance, target acquisition, and precision-guided munition systems.

OVERVIEW

This section addresses technologies for chemical defense systems; chemical detection, warning, and identification; and obscurants. Chemical material production is not covered because the United States is a party to the Chemical Weapons Convention (CWC) and has renounced the development, stockpiling, transfer, and use of chemical weapons. Production is covered in the list of Militarily Critical Technologies, Weapons of Mass Destruction Technologies, as is stabilization, dissemination, and dispersion. The chemical defense systems section includes technologies that are designed to protect forces when contamination cannot be avoided and provide prophylaxis and therapy to counter threat agents for any affected forces. These chemical defense systems technologies also cover decontamination to ensure rapid force reconstitution. Chemical detection, warning, and identification technologies covered in this section can provide real-time capability to detect, identify, locate, and quantify chemical threats. Sensors must be integrated with an information-processing system to analyze the threat, identify potentially affected units, and pass on alarms and warnings to implement protective measures. It is also important to identify when an "all clear" can be sounded after an attack. Both detection and protection apply to personnel operating on the ground, at sea, in the air, and in shelters and large enclosures. Although many sensor and defense technologies have commercial applications, military requirements are much more stringent. Selected toxic chemicals, which are of concern for defense and detection, are presented in tabular form (see Figure 5.0-1). Toxic chemicals are extracted from the CWC schedules, with two additions (Novichok agents and carbamates). Detection and identification technologies can also be used for chemical weapons inspection and monitoring as required by the CWC. Obscurants, or materials that limit or prevent reconnaissance, surveillance, target acquisition, and weapon guidance by degrading or defeating sensors that operate in any part of the electromagnetic spectrum, are included as well.

BACKGROUND

Until the 1995 attempts at terrorism by the Japanese cult Aum Shinrikyo, virtually all uses of chemical weapons have been as tactical weapons by nations. These have ranged from attempts to break the stalemate in World War I to their use by Iraq to blunt Iranian human wave attacks in the Iran-Iraq War (1982–87). The major protagonists in World War II did not employ chemical weapons. Between World Wars I and II, two signatories of the Geneva Protocol (Italy and Japan) employed chemical weapons. Typically, nations have employed them against unprotected targets and not against an equally well-armed nation—arguably an example of mutual deterrence.

Although there have been charges of chemical weapon use in virtually every conflict in recent decades, most have not been substantiated by clinical or physical evidence, although this can be difficult to recover.

Despite the importance of detection, the major technological advances for detection, identification, and warning are relatively recent. Initially, detectors were papers impregnated with a dye that underwent a color change when exposed to a chemical agent. By World War II, air-sampling tubes filled with liquids that changed color on exposure were available, as well as rather crude, wet-chemical point detectors. The advent of the nerve gases after World War II led to the development of sensitive enzyme detection techniques and point detection alarms. The latter were based on wet chemistry and required extensive servicing. Recent advances in microprocessing, miniaturization and fieldable instrumentation techniques have made remote and area sensing of chemical agents feasible. Generally, sensors produced for military applications have been fail-safe, prone to false positives but free from false negatives.

A major advance in individual physical protection occurred very early in the history of modern chemical warfare with the development of the activated charcoal filtered gas mask. Many incremental improvements to aid in effectiveness against particular agents and to add communication and creature comforts followed. Impregnated clothing for protection against percutaneous poisoning was another rather early development that continues to be improved incrementally by increasing protection factors, comfort, and wearability.

Nerve Agents	(CAS registry number)
O-Alkyl ($\leqq C_{10}$, incl. cycloalkyl) alkyl	
(Me, Et, n-Pr or Pr)-phosphonofluoridates	
e.g., GB or Sarin: O-Isopropyl methylphosphonofluoridate	(107-44-8)
GD or Soman: O-Pinacolyl methylphosphonofluoridate	(96-64-0)
O-Alkyl ($\leqq C_{10}$, incl. cycloalkyl) N,N-dialkyl	
(Me, Et, n-Pr or Pr) phosphoramidocyanidates	
e.g., GA or Tabun: O-Ethyl N,N-dimethyl phosphoramidocyanidate	(77-81-6)
O-Alkyl (H or $\leqq C_{10}$, incl. cycloalkyl) S-2-dialkyl	
(Me, Et, n-Pr or Pr)-aminoethyl alkyl	
(Me, Et, n-Pr or Pr) phosphonothiolates and	
corresponding alkylated or protonated salts	
e.g., VX: O-Ethyl S-2-diisopropylaminoethyl methyl phosphonothiolate	(50782-69-9)
Others	
Novichok agents	
Carbamates	
Vesicants	
Sulfur mustards:	
2-Chloroethylchloromethylsulfide	(2625-76-5)
Mustard gas: Bis(2-chloroethyl)sulfide	(505-60-2)
Bis(2-chloroethylthio)methane (63869-13-6)	
Sesquimustard: 1,2-Bis(2-chloroethylthio)ethane	(3563-36-8)
1,3-Bis(2-chloroethylthio)-n-propane	(63905-10-2)
1,4-Bis(2-chloroethylthio)-n-butane	(142868-93-7)
1,5-Bis(2-chloroethylthio)-n-pentane	(142868-94-8)
Bis(2-chloroethylthiomethyl)ether	(63918-90-1)
O-Mustard: bis(2-chloroethylthioethyl)ether	(63918-89-8)
Lewisites:	
Lewisite 1: 2-Chlorovinyldichloroarsine	(541-25-3)
Lewisite 2: Bis(2-chlorovinyl)chloroarsine	(40334-69-8)
Lewisite 3: Tris(2-chlorovinyl)arsine	(40334-70-1)
Nitrogen mustards:	
HN1: Bis(2-chloroethyl)ethylamine	(538-07-8)
HN2: Bis(2-chloroethyl)methylamine	(51-75-2)
HN3: Tris(2-chloroethyl)amine	(555-77-1)
Toxins (other toxins covered in Section 3, Biological Technology)	
Saxitoxin	(35523-89-8)
Ricin	(9009-86-3)
Choking Agent	
Phosgene: carbonyl dichloride	(75-44-5)
Blood Agents	
Cyanogen chloride	(506-77-4)
Hydrogen cyanide	(74-90-8)

Figure 5.0-1. Selected Toxic Chemicals Requiring Detection, Warning, Identification, and Defense

SECTION 5.1—CHEMICAL DEFENSE SYSTEMS

Highlights

- Chemical defense has three commodity areas: contamination avoidance, force protection (individual, collective and medical support), and restoration (decontamination).
- The goal of individual and collective protection is to insulate U.S. ground, air, and sea forces from chemical agents by using clothing ensembles and respirators for individuals and collective filtration systems for groups.
- Decontamination technologies assist in eliminating contamination and returning forces and equipment to operationally ready status.

OVERVIEW

According to the Department of Defense Chemical and Biological Defense Program *Volume I: Annual Report to Congress,* April 2002, "The vision of the Department of Defense (DoD) Chemical and Biological Defense Program (CBDP) is to ensure U.S. military personnel are the best equipped and best prepared force in the world for operating in future battlespaces that feature chemically and biologically contaminated environments.” The three tenets of CB defense are: contamination avoidance, force protection (individual, collective and medical support), and restoration. All are addressed in this section. Protective clothing used in supporting missions (e.g., explosive ordnance disposal) is also covered. Contamination avoidance is based on sensors providing real-time detection and identification of toxic agents (see Section 5.2). The goal of individual and collective protection is to insulate U.S. ground, air, and sea forces from chemical and biological agents by using clothing ensembles and respirators for individuals and collective filtration systems for groups. Military requirements for individual protection differ from those used in commercial applications. Manufacturers deal with known processes, inputs, and outputs. Military and civilian first responders must be prepared to respond to unknown threats, including new agents in unknown quantities, anywhere and at any time. Because most types of protective gear limit human performance capabilities, sometimes up to 50 percent, more advanced efforts are aimed at accounting for these limitations and increasing the comfort/wear time and freedom of action. Decontamination technologies that ensure rapid and effective force reconstitution are also included.

BACKGROUND

Chemical agents may enter the body by several routes. When inhalable, vapors and aerosols may be absorbed by any part of the respiratory tract. Vapor absorption may occur through the eyes and mucosa of the nose and mouth. Liquid droplets and liquids sorbed on solid particles can be absorbed by the surface of the skin, eyes, and mucous membranes. Chemical agents that contaminate food and drink can be absorbed through the gastrointestinal tract. Finally, wounds or abrasions are presumed to be more susceptible to absorption than the intact skin.

Decontamination issues have been explored since the beginning of modern chemical warfare. After years of research worldwide, simple principles that consistently produce good results still apply. The first, without equal, is timely physical removal of the agent. To remove the substance by the best means available is the primary objective. Chemical destruction (detoxification) of the offending agent is a desirable secondary objective. Physical removal is imperative because none of the chemical means of destroying these agents does so instantaneously. Although decontamination preparations such as fresh hypochlorite react rapidly with some agents (e.g., the half-life of VX in hypochlorite at a pH of 10 is 1.5 minutes), the half times of destruction of other agents, such as mustard, are much longer. If a large amount of agent is present initially, a longer time is needed to completely neutralize the agent to a harmless substance.

Timely use of water, soap and water, or flour, followed by wet tissue wipes, produced results equal to, nearly equal to, or in some instances, better than those produced by the use of Fuller's Earth, Dutch Powder, and other compounds. (Fuller's Earth and Dutch Powder are decontamination agents currently fielded by some European countries.)

LIST OF MCTL TECHNOLOGY DATA SHEETS
5.1. CHEMICAL DEFENSE SYSTEMS

Chemical Protection

Decontamination

MCTL DATA SHEET 5.1-1. PROTECTIVE MASKS

Critical Technology Parameter(s)	Provide protection for 24 hours against 10,000 mg-min/m^3 challenge for toxic vapors and aerosols.
Critical Materials	Butyl rubber, silicone rubber, and chemically resistant polymeric materials; filter materials, sorbents; filtration media.
Unique Test, Production, Inspection Equipment	Simulated agents; actual agent testing for breakthrough time; leakage testers; manikin-face model for mask and suit design; particle-size-analysis equipment.
Unique Software	Software for generating facial contours.
Major Commercial Applications	HazMat and first responders.
Affordability Issues	Not an issue for military, although it is for HazMat and first responders.
Export Control References	WA ML 7, 21, 22; WA Cat 1A, D, E; USML XIV; CCL Cat 1A.

BACKGROUND

Protective masks have been used since World War I to provide military forces with respiratory protection from toxic substances. Masks protect the respiratory system by preventing the inhalation of toxic chemical vapors and aerosols. They protect eyes and face from direct contact with chemical agents as well. Important considerations in mask design are the ability to don the mask and hood quickly, communications, respiration, performance degradation, and the ability to consume fluids while the mask is in place. Masks must be compatible with operational missions and equipment (e.g., night vision goggles).

MCTL DATA SHEET 5.1-2. PROTECTIVE CLOTHING, BATTLEFIELD

Critical Technology Parameter(s)	Provide protection on the battlefield for 24 hours against 10 g/m^2 challenge by all liquid agents and 10,000 mg-min/m^3 challenge for toxic vapors and aerosols; 30-day consecutive use; launderability; durability.
Critical Materials	Impregnated activated carbon (charcoal); charcoal-activated cloth; semipermeable membranes; polymers.
Unique Test, Production, Inspection Equipment	Simulated agents; actual agent testing; human-use protocols; particle size analysis equipment; penetration testing; articulated manikin to simulate soldier movement.
Unique Software	None identified.
Major Commercial Applications	HazMat and first responders [charcoal and carbon are not Occupational Safety and Health Administration (OSHA) approved].
Affordability Issues	Not an issue for military but is for HazMat and first responders.
Export Control References	WA ML 7, 21, 22; WA Cat 1A, D, E; USML XIV; CCL Cat 1A.

BACKGROUND

Protective clothing (garments, gloves, boots) provides protection from contact with chemical agents as well as flame protection with a minimum amount of heat stress. Ensembles must be durable and able to be laundered and decontaminated. Battlefield garments are made of permeable materials as a compromise between mission accomplishment and protection. The outer layer absorbs, retains, and spreads out the liquid contamination from droplets, allowing the charcoal impregnated layer beneath to adsorb toxic vapors.

MCTL DATA SHEET 5.1-3. FULL PROTECTION (ENCAPSULATION) SUIT

Critical Technology Parameter(s)	Provide splash and vapor protection against exposure to liquid agent—10 g/m^2 HD, VX, GB, L agent challenge for 2 to 4 hours.
Critical Materials	Nomex, Teflon, neoprene/butyl.
Unique Test, Production, Inspection Equipment	Simulated agents; actual agent testing; human-use protocols; particle-size-analysis equipment; penetration testing.
Unique Software	None identified.
Major Commercial Applications	First responders; chemical industry; emergency operations in polluted areas.
Affordability Issues	Not an issue.
Export Control References	WA ML 7, 21, 22; WA Cat 1A, D, E; USML XIV; CCL Cat 1A.

BACKGROUND

Full-protection suits provide complete body protection from chemical and biological agents and industrial chemicals. These impermeable suits provide protection against fuels, petroleum, oils, and lubricants (POLs) and industrial chemicals. They are used for short-term operations [immediately dangerous to life and health (IDLH) environments].

MCTL DATA SHEET 5.1-4. COLLECTIVE PROTECTION

Critical Technology Parameter(s)	Prevent >99.9% of toxic agents from entering common areas.
Critical Materials	Impregnated carbon filters; polyethylene; fluoro-polymer/aramid laminate.
Unique Test, Production, Inspection Equipment	Simulated agents; actual agents.
Unique Software	None identified.
Major Commercial Applications	State and local government emergency response centers.
Affordability Issues	Power supply and the design and sealing of large volumes.
Export Control References	WA ML 7, 21, 22; WA Cat 1A, D, E; USML XIV; CCL Cat 1A.

BACKGROUND

In addition to individual protection, groups of people working in proximity to one another need protection from chemical and biological agents. Fixed locations such as command centers need to be free from chemical contamination. Deployable systems are required for missions, such as medical care, where the facility deploys to the field to assist casualties from both conventional ordnance and chemical or biological attack. Vehicles on the battlefield need protection, too.

People under a roof, e.g., indoors or in covered vehicles, are not only protected against CW agents in liquid form but also receive a certain degree of protection against aerosols and gases since the air turnover in such spaces is lower. The concentration increases more slowly and there is not such a hurry to don protective masks.

MCTL DATA SHEET 5.1-5. REGENERATIVE FILTRATION—PRESSURE SWING ADSORPTION

Critical Technology Parameter(s)	Remove toxic material to lower than detectable levels without needing replacement filters.
Critical Materials	Compressed air from vehicle or alternative source.
Unique Test, Production, Inspection Equipment	Simulated agents.
Unique Software	None identified.
Major Commercial Applications	HazMat and first responders; hydrogen, nitrogen, or oxygen generation; treatment of landfill gases.
Affordability Issues	Reduces the logistics burden of filters that must be replaced.
Export Control References	USML XIV; WA ML 7.

BACKGROUND

Regenerative filtration is filtration that can be used more than once without being replaced. Pressure swing adsorption (PSA) is one technology that can be used for filters that regenerate.

MCTL DATA SHEET 5.1-6. DECONTAMINANTS—EQUIPMENT

Critical Technology Parameter(s)	Remove or neutralize >99.9% of toxic material.
Critical Materials	Sorbent powder; sodium hydroxide; SuperTropical Bleach (STB); DS2 and DS2P; Fuller's Earth; GD-5; CASCAD; RSDL; enzymes; bio-based materials.
Unique Test, Production, Inspection Equipment	Simulated agents; actual agents.
Unique Software	None identified.
Major Commercial Applications	Environmental cleanup; first responders.
Affordability Issues	GD–5 is very expensive (approx $1,100 for 5 gallons).
Export Control References	WA ML 7, 21, 22; WA Cat 1A, D, E; USML XIV; CCL Cat 1A.

BACKGROUND

Once equipment is contaminated with any type of toxic substance, it must be decontaminated to prevent further damage and to avoid the spread of the contamination. There are a number of methods that can be used to reduce, neutralize or eliminate toxic chemicals. CW agents can be washed and rinsed away, dried up, absorbed, or removed by heat treatment.

MCTL DATA SHEET 5.1-7. DECONTAMINANTS—PERSONNEL

Critical Technology Parameter(s)	Remove >99.9% of toxic material or neutralize it.
Critical Materials	AMBERGARD XE–555 resin; GD-5; RSDL.
Unique Test, Production, Inspection Equipment	Simulated agents; actual agents.
Unique Software	None identified.
Major Commercial Applications	First responders (use of M291 not approved).
Affordability Issues	Materials for sorbent decontamination systems are generally not expensive. GD–5 is very expensive (approx $1,100 for 5 gallons).
Export Control References	WA ML 7, 21, 22; WA Cat 1A, D, E; USML XIV; CCL Cat 1A.

BACKGROUND

Contamination must be eliminated from personnel as soon as possible after an attack or exposure to toxic substances. Although it may be possible to “fight dirty,” emphasis remains on avoiding contamination and limiting it as much as possible.

SECTION 5.2—CHEMICAL DETECTION, WARNING, AND IDENTIFICATION

Highlights

- The cornerstone of U.S. chemical defense is early detection and warning to provide situational awareness and allow U.S. forces to avoid the threat.
- Technology focus is on detection, warning, and identification across the spectrum of chemical agents, as well as on the integration of chemical detectors into various platforms, individual clothing, and the C4I network.
- To ensure detection and identification, a multi-system of sensors is needed, each of which looks at a different part of the suspect molecule.
- Detectors for toxic agents must have a short response time combined with a low rate of false alarms and must meet appropriate size, weight, and power requirements.
- Recent advances in signal processing and presentation have enhanced detection.

OVERVIEW

Technologies used for detection and identification of toxic chemical agents are included in this section. Detectors used at designated locations are called point detectors and may be fixed or hand held devices. Standoff detectors provide early, wide-area warning of an attack. Detection technologies must be capable of sensing and mapping large areas of vapor and liquid chemical-agent contamination. Identification systems use immunochemical or gene probes, ion mobility spectrometry, mass spectroscopy or infrared spectroscopy techniques. Detector/sensor systems rely on ion mobility, flame photometry, colorimetric or electrochemistry techniques. No single sensor detects all chemical agents of interest. Detectors for toxic chemical agents must have a short response time with a low rate of false alarms and meet appropriate size, weight, and power requirements. Detection equipment must be integrated with a command and control system to ensure proper evaluation of the information and that an alarm is sounded when appropriate. This is essential for contamination avoidance. Other unknown factors include location and concentration or quantity of the agent. These are crucial parameters for command decisions. Current DoD technology focus is on detection, warning, and identification across the spectrum of chemical and biological agents as well as on the integration of chemical and biological detectors into various platforms, individual clothing, and the command, control, communications, computers, and intelligence (C4I) network. Identification is critical to timely and appropriate medical response.

This section also covers technologies used to inspect for and monitor the development of chemical weapons. In some cases these allow nondestructive evaluations of munitions and other containers to determine their contents without opening. These technologies have a role in explosive ordnance disposal as well as chemical weapons detection.

The CWC contains a verification regime to enhance the security of States' Parties to the convention and to preclude the possibility of clandestine chemical weapons production, storage, and use. It includes routine inspections of declared facilities and consultations, cooperation and fact finding under Article IX of the Convention. Challenge inspections (that allow a State Party to request and have conducted an international inspection of a facility or location in another State Party in order to clarify and resolve questions of possible noncompliance) are one tool available under Article IX.

Although there are similarities between technologies used for the inspection and monitoring of chemical agents and the detection of chemical agent use in a wartime scenario, there are also differences. The warfighter is mostly concerned with adversary employment of chemical weapons against friendly forces, although explosive ordnance disposal is also a concern. Time is of the essence, and detection must be rapid with a minimum of false alarms.

Technologies used to monitor arms control agreements, however, usually do not place the same premium on speed. Emphasis is on legal proof of production and storage. Although samples must be analyzed in a minimum amount of time, the analysis is not a matter of life and death as it is in combat. Equipment must be taken into the field, but it does not have to be made rugged to the same extent as military battlefield detectors. Quality assurance and accountability are paramount in the verification regime.

LIST OF MCTL TECHNOLOGY DATA SHEETS
5.2. DETECTION, WARNING, AND IDENTIFICATION

MCTL DATA SHEET 5.2-1. FLAME PHOTOMETRY AND GAS CHROMATOGRAPHY/FLAME PHOTOMETRY (GC-FPD)

Critical Technology Parameter(s)	Sensitivity and response time (for AP2C): GA, GB, GD, and GF: neat and thickened, 0.1 mg/m^3, 2 sec; VX: 0.15 mg/m^3, 2 sec; HD: minimum related to the concentration of the H mixture, 2 sec; Blister: neat and thickened, 0.4 mg/m^3, 2 sec.
Critical Materials	None identified.
Unique Test, Production, Inspection Equipment	Database development and live agent testing.
Unique Software	Spectrum recognition algorithms.
Major Commercial Applications	Environmental monitoring; process control; security and law enforcement, e.g., contraband (drugs, explosives) detection.
Affordability Issues	None identified.
Export Control References	WA ML 7, 21; WA Cat 1A, D, E; AG List; USML XIV; CCL Cat 1A, D, E.

BACKGROUND

Flame photometry is one of the oldest and simplest methods of chemical analysis still in use today. Each chemical element emits light at various wavelengths when burned in a flame. Sulfur and phosphorous emit unique and characteristic wavelengths of light when burned in a hydrogen-rich flame. By installing wavelength-selective filters between the flame and the light detector, a photometer specific for selected elements can be made.

MCTL DATA SHEET 5.2-2. MASS SPECTROMETRY (MS) AND GAS CHROMATOGRAPHY/MASS SPECTROMETRY (GC-MS)

Critical Technology Parameter(s)	Detect ion level: 1–1000 picograms of CW agent by GC-MS; 0.01 mg/m^{3}for nerve agents and 0.1 mg/m^3 for blister agents by direct aspiration into MS.
Critical Materials	None identified.
Unique Test, Production, Inspection Equipment	Live agent testing.
Unique Software	Spectrum recognition algorithms; blinding software for OPCW inspection purposes.
Major Commercial Applications	Environmental monitoring; process control; field analysis; analytical chemistry.
Affordability Issues	Expensive.
Export Control References	WA ML 7, 21; WA Cat 1A, D, E; AG List; USML XIV; CCL Cat 1A, D, E.

BACKGROUND

A mass spectrometer is an instrument that measures the mass-to-charge ratios of ions formed from the analyte molecule by some type of ionizing technique (typically electron ionization). The mass spectrometer consists of four basic parts: a sample inlet system; an ion source; a mass analyzer; and an ion detector. Analyte molecules are split into charged fragments by the ionizing source. The charged fragments constitute a spectrum of mass-to-charge ratios unique to the analyte molecule. Comparison of the mass spectrum for an unknown molecule to a library of mass spectral data from known chemicals allows identification of the unknown molecule.

Gas phase samples may be introduced directly into the MS through a membrane interface, or the MS may be interfaced to a gas chromatograph (GC). The combination of GC with MS simplifies the mass spectra interpretation because only a few compounds are (and ideally only one compound is) being introduced into the MS at a time. The GC separates multiple components in a sample before they are introduced into the MS. The combination of mass spectral identification and GC elution time provides a high probability of specific identification of a substance.

MCTL DATA SHEET 5.2-3. ION MOBILITY SPECTROMETRY (IMS)

Critical Technology Parameter(s)	Sensitivity: G Agents: 0.10 mg/m^3 <30 sec; VX: 0.04 mg/m^3 <30 sec; H agents: 2.00 mg/m^3 <15 sec; Lewisite: 2.00 mg/m^3 <15 sec.
Critical Materials	None identified.
Unique Test, Production, Inspection Equipment	Database development, ionization source; live agent vapor generator and concentration control; clean room for manufacturing.
Unique Software	Spectrum-recognition algorithms.
Major Commercial Applications	Environmental monitoring; process control; security and law enforcement, e.g., contraband (drugs, explosives) detection.
Affordability Issues	Moderately expensive (ICAM has brought down maintenance costs).
Export Control References	WA ML 7, 21; WA Cat 1A, D, E; AG List; USML XIV; CCL Cat 1A, D, E.

BACKGROUND

Ion Mobility Spectrometry systems such as the Chemical Agent Monitor (CAM) offer point detection of general classes of agent in the field. IMS offers the probability of detection with very low false-negative rates. Typically, an IMS device is not used for low-level detection but is used to determine the location of contamination and to ascertain the effectiveness of decontamination. This is normally accomplished by using a radioactive source to ionize chemical substances drawn into the instrument and then measuring the time it takes the particular ionized particle to traverse a drift tube and register on a detector. Each ion type has a characteristic mobility time and can be measured semiquantitatively.

MCTL DATA SHEET 5.2-4. PASSIVE INFRARED

Critical Technology Parameter(s)	Detect vapors at distances up to 5 km (nerve: 90 mg/m^3; blister: 500 mg/m^3 for L and 1,500 mg/m^3 for HD).
Critical Materials	None identified.
Unique Test, Production, Inspection Equipment	Database development.
Unique Software	Spectrum and background recognition algorithms.
Major Commercial Applications	Environmental monitoring.
Affordability Issues	Expensive.
Export Control References	WA ML 7, 21; WA Cat 1A, D, E; AG List; USML XIV; CCL Cat 1A, D, E.

BACKGROUND

Standoff detection is needed to detect the use of chemical weapons at a distance and enable forces to avoid exposure. Infrared (IR) detection measures the characteristic absorption or emission bands for a gaseous substance. By ascertaining the wavelength and strength of these bands, vapors can be detected and partially analyzed or identified.

MCTL DATA SHEET 5.2-5. SURFACE ACOUSTIC WAVE (SAW)

Critical Technology Parameter(s)	Sensitivity: VX and G agents: 1 mg/m^3 <10 sec, 0.1 mg/m^3 <30 sec, 0.04 mg/m^3 <90 sec; Blister and Lewisite: 50 mg/m^3 <10 sec, 2 mg/m^3 <120 sec.
Critical Materials	New coating materials.
Unique Test, Production, Inspection Equipment	Simulant and live agent testing
Unique Software	Pattern recognition, neural networks.
Major Commercial Applications	Monitoring hazardous chemical vapors, potential fires, and environmental pollutants.
Affordability Issues	At present, moderately expensive.
Export Control References	WA ML 7, 21; WA Cat 1A, D, E; AG List; USML XIV; CCL Cat 1A, D, E.

BACKGROUND

Surface acoustic wave (SAW) is a technology that can provide an individual point alarm for the soldier or civilian first responder. Although false positives would remain a problem, the system could prove extremely useful in surveying suspected contaminated environments. System detection limits for SAW are in the parts per trillion area. The system operates autonomously with a simple gas-sampling system and without the need for support gases. Individual SAW devices operate by generating surface mechanical oscillations in piezoelectric quartz with frequencies in the megahertz range. Coating the SAW devices with different polymeric materials that selectively absorb different gases allows gas detection by changes in SAW frequency. Arrays of polymer-coated SAW devices detect different gases, and pattern-recognition techniques interpret data and identify unknowns.

MCTL DATA SHEET 5.2-6. PORTABLE ISOTOPIC NEUTRON SPECTROSCOPY

Critical Technology Parameter(s)	Assay unknown contents of munitions in 100 to 1,000 sec.
Critical Materials	Neutron source (^{252}Cf); liquid nitrogen.
Unique Test, Production, Inspection Equipment	None identified.
Unique Software	Database of known signatures.
Major Commercial Applications	Hazardous material identification by law-enforcement agencies and fire departments.
Affordability Issues	Expensive (approx $100 K each).
Export Control References	WA ML 7, 21; WA Cat 1A, D, E; AG List; USML XIV; CCL Cat 1A, D, E.

BACKGROUND

The portable isotropic neutron spectroscopy (PINS) uses neutron radiation from a small radioisotope source (^{252}Cf) to probe the contents of a suspect container. The chemical elements inside the container are revealed by their characteristic gamma-ray signature as measured by the instrument's high-resolution, high-purity germanium spectrometer. The system's computer then infers the contents (single compound or mixture) from the elemental data.

MCTL DATA SHEET 5.2-7. RAMAN SPECTROSCOPY

Critical Technology Parameter(s)	Analysis time: a few seconds per sample.
Critical Materials	None identified.
Unique Test, Production, Inspection Equipment	None identified.
Unique Software	Database.
Major Commercial Applications	Fuel analysis; in situ process control (rubber, latex, etc.); pharmaceuticals; chemicals; quality control (chemical composition); law enforcement (drugs and explosives); medical (monitoring, diagnostics); environmental (water quality, environmental remediation).
Affordability Issues	Not an issue.
Export Control References	WA ML 7, 21; WA Cat 1A, D, E; AG List; USML XIV; CCL Cat 1A, D, E.

BACKGROUND

Raman spectroscopy is a universal analytical technique for identification of molecules in gases, liquids, and solids by scattering of laser light. Raman spectroscopy uses a laser to generate an intense beam of monochromatic light that is directed onto a target material. A small fraction of this excitation light is scattered and shifted into different wavelengths by the target material. A study of this scattered light's intensity and wavelength (i.e., the Raman spectrum) can provide both qualitative and quantitative information about the materials under investigation. Measurements can be made directly on solids and liquids without the need for sample preparation.

MCTL DATA SHEET 5.2-8. SWEPT FREQUENCY ACOUSTIC INTERFEROMETRY

Critical Technology Parameter(s)	90% reliability with a 90% confidence level; response time of less than 1 minute (approximately 20 sec).
Critical Materials	None identified.
Unique Test, Production, Inspection Equipment	None identified.
Unique Software	Origin (from Origin Lab Corp., formerly Microcal Software, Inc.) data analysis software; database.
Major Commercial Applications	Basic research; biomedical and environmental sensors; chemical, food and beverage, pharmaceutical and petroleum industries; and Customs for drug interdiction.
Affordability Issues	None identified.
Export Control References	WA ML 7, 21; WA Cat 1A, D, E; AG List; USML XIV; CCL Cat 1A, D, E.

BACKGROUND

Swept-frequency acoustic interferometry (SFAI) is a novel adaptation of an ultrasonic interferometry technique developed decades ago for determining sound velocity and absorption in liquids and gases. The underlying principle is the establishment of a standing acoustic wave inside a resonator cavity, using external excitation and simultaneous detection. It works through the application of swept-frequency electric excitation, in a frequency range from 1 kHz to 15 MHz, to a piezoelectric transducer attached to the outside of the container. At certain frequencies, the signal produces acoustic resonance in the liquid inside the container. The result is a series of resonance peaks in a spectrum. These are detected by a second piezoelectric transducer that works as a receiver. (See http://www.originlab.com/www/resources/casestudies/ sinha.asp).

MCTL DATA SHEET 5.2-9. ENZYMATIC AND COLORIMETRIC CHEMISTRY

Critical Technology Parameter(s)	Detect and identify within 10 minutes.
Critical Materials	None identified.
Unique Test, Production, Inspection Equipment	None identified.
Unique Software	None identified.
Major Commercial Applications	Airport security.
Affordability Issues	Inexpensive.
Export Control References	WA ML 7, 21; WA Cat 1A, D, E; AG List; USML XIV; CCL Cat 1A, D, E.

BACKGROUND

Detector kits that use enzymatic chemistry can be used to locate and identify chemical hazards (reconnaissance), to determine when it is safe to unmask, and to monitor decontamination effectiveness.

MCTL DATA SHEET 5.2-10. ION TRAP SECONDARY ION MASS SPECTROMETRY

Critical Technology Parameter(s)	Parts per million level; 1-mg sample.
Critical Materials	None identified.
Unique Test, Production, Inspection Equipment	None identified.
Unique Software	Databases
Major Commercial Applications	Environmental remediation.
Affordability Issues	Cost effective based on rapid analysis time and moderate instrument cost.
Export Control References	WA ML 7, 21; WA Cat 1A, D, E; AG List; USML XIV; CCL Cat 1A, D, E.

BACKGROUND

The principle behind ion trap secondary ion mass spectrometry (IT-SIMS) is particle bombardment and desorption of surface ions. A polyatomic projectile is used for "sputtering" contaminant species from sample surfaces. The sputtered ions are trapped and scanned by mass. The contaminant ion signal must be separated from the endogenous chemical background. The isolated ions are fragmented in the trap. Fragmentation is specific to the contaminant.

MCTL DATA SHEET 5.2-11. SAMPLE COLLECTION

Critical Technology Parameter(s)	Collects and concentrates 1–10 μm particles into liquid medium.
Critical Materials	None identified.
Unique Test, Production, Inspection Equipment	Aerosol samplers able to collect less than or equal to 10 μm diameter particles into a liquid.
Unique Software	None identified.
Major Commercial Applications	Environmental monitoring; process control.
Affordability Issues	Not an issue.
Export Control References	WA ML 7, 21; WA Cat 1A, D, E; AG List; USML XIV; CCL Cat 1A, D, E.

BACKGROUND

Sample collection includes the means of taking a sample of a substance in preparation for processing and analysis.

MCTL DATA SHEET 5.2-12. SAMPLE PROCESSING AND ANALYSIS

Critical Technology Parameter(s)	Completion within 10 minutes.
Critical Materials	None identified.
Unique Test, Production, Inspection Equipment	Ion trap mass spectrometers capable of scanning samples from 40–1,024 daltons in milliseconds; pyrolyzers; chemical and enzyme detection kits.
Unique Software	Spectrum-recognition algorithm.
Major Commercial Applications	Environmental monitoring; process control.
Affordability Issues	Not an issue.
Export Control References	WA ML 7, 21; WA Cat 1A, D, E; AG List; USML XIV; CCL Cat 1A, D, E.

BACKGROUND

Sample processing and analysis includes all of the processes and techniques used to prepare a sample and to analyze its contents.

MCTL DATA SHEET 5.2-13. C4I SYSTEMS

Critical Technology Parameter(s)	Provide communications interface to NBC sensors, provide warning of chemical and nuclear attacks throughout the battlefield, and automatically generate NBC–1/NBC–4 reports over existing tactical communications.
Critical Materials	None identified.
Unique Test, Production, Inspection Equipment	None identified.
Unique Software	System dependent (NBC–Analysis; SNOOPER 2.0, etc.).
Major Commercial Applications	First responders.
Affordability Issues	Not an issue.
Export Control References	WA ML 7; WA Cat 1; USML XIV; CCL Cat 1.

BACKGROUND

No matter what type of equipment is used to detect and identify a toxic chemical agent, the information must be disseminated to the appropriate people in a timely manner. Likewise, it is imperative to transmit an “all clear” as soon as possible to preclude troops from working in protective clothing for an extended amount of time. Much effort has been devoted to the development of a system to transmit information on chemical weapon use and a system or systems to ensure that all communication needs are coordinated.

MCTL DATA SHEET 5.2-14. RECONNAISSANCE SYSTEMS

Critical Technology Parameter(s)	Detects, identifies, marks, samples, and reports chemical and radiological contamination on the battlefield using a sophisticated suite of nuclear and chemical alarms and detectors that have been integrated within the vehicle chassis. Detects chemical agent clouds as far as 5 km away.
Critical Materials	None identified.
Unique Test, Production, Inspection Equipment	None identified.
Unique Software	None identified (different vehicles use their own software).
Major Commercial Applications	Domestic preparedness and response teams.
Affordability Issues	Block II: significantly reduced operational, sustainment, and life-cycle costs.
Export Control References	WA ML 7, 21; WA Cat 1A, D, E; AG List; USML XIV; CCL Cat 1A, D, E.

BACKGROUND

Various solutions have been used to detect, identify, mark and report contamination on the battlefield. A key part of this mission has been performed by mobile systems. Reconnaissance vehicles are capable of detecting chemical contamination in their immediate environment through point detection and at a distance through the use of a standoff detector. They automatically integrate contamination information from sensors with input from on-board navigation and meteorological systems and transmit information to a command and control system.

SECTION 5.3—OBSCURANTS

Highlights

- If employed properly, obscurants can negate the value of high-technology reconnaissance, target acquisition, and precision-guided munition systems.
- Obscurants can be used to enhance friendly operations and degrade enemy operations.

OVERVIEW

Obscurants are materials that limit or prevent reconnaissance, intelligence surveillance, target acquisition, and weapons guidance. They can be used on the battlefield to enhance friendly operations and degrade enemy operations. Obscurants can be identified by their impact on the electromagnetic spectrum, for example, on ultraviolet (UV), visible, IR, millimeter wave (mmW), centimeter wave (cmW), above cmW, and multispectral wavelengths. The major near-term U.S. efforts consist of the following: production and fielding of a large area visual/IR obscurant generator (mechanized and motorized); production and fielding for armored vehicles of a self-protection grenade that defeats sensors in the visual, IR, and mmW frequencies; and demonstration of the feasibility of an mmW obscurant-generating system to prevent threat radars from observing, acquiring, targeting, and tracking friendly targets. A long-term goal is to validate the capability of multispectral materials to obscure or defeat enemy reconnaissance, intelligence, surveillance, targeting, and acquisition assets in broad bands of the electromagnetic spectrum from visual through mmW.

BACKGROUND

Smoke and obscurants have been used in wars dating back to the ancient Greeks. Smoke is used as camouflage, as blinding smoke laid directly on enemy positions, and as decoy smoke used to confuse and mislead enemy forces. These basic smoke applications are still relevant to increased survivability, increased maneuver time for the attacker, and protected forward assembly areas and high-priority rear areas for the defense.

Smoke particles scatter or absorb radiant energy used by troops and smart weapons for target acquisition and for weapons guidance and control. Smart weapon sensors operate in three main parts of the electromagnetic spectrum: visible and near IR, mid and far IR, and millimeter wavelengths. The most effective scattering smokes are aerosols that are the same size as the operating wavelengths of the sensor to be defeated. The best smoke for the visible spectrum may be transparent in the far IR. The entire chain of electro-optical, IR, and mmW devices linking a smart weapon to a target are susceptible to smoke and obscurants. In addition to having the capability of absorption, some smokes emit heat that can blind or clutter thermal images of targets.

Reflection of laser or radar beams from smoke clouds can produce false targeting information for smart weapons. There are no smart weapons that cannot be blinded and defeated by smoke. Obscurants allow a defender to take advantage of technology overmatch. In Desert Storm, U.S. ground forces used the technology of IR viewers in combination with an effective visual obscurant (they fought at night) to achieve dramatic results.

LIST OF MCTL TECHNOLOGY DATA SHEETS
5.3. OBSCURANTS

MCTL DATA SHEET 5.3-1. MID- AND FAR-INFRARED—SCATTERING, ABSORBING

Critical Technology Parameter(s)	Ext_{IR} >1.5; packing density >50% of the material density; dissemination efficiency >50% of the packaged material.
Critical Materials	Conductive flakes (brass, aluminum, graphite); sub-μm-diameter conductive fiber.
Unique Test, Production, Inspection Equipment	Aerosol test chambers, transmissometers; test ranges; nephelometers.
Unique Software	Obscurant modeling.
Major Commercial Applications	None identified.
Affordability Issues	Inexpensive, especially in relation to the assets that are protected.
Export Control References	WA ML 4; USML XXI.

BACKGROUND

Obscurants can be identified by their impact on the electromagnetic spectrum, for example, on ultraviolet (UV), visible, IR, millimeter wave (mmW), centimeter wave (cmW), above cmW, and multispectral wavelengths. This data sheet covers those in the mid- and far-infrared wavelengths.

MCTL DATA SHEET 5.3-2. MILLIMETER WAVE—SCATTERING

Critical Technology Parameter(s)	Ext_{mm} >2; packing density >50% of the material density; dissemination efficiency >50% of the packaged material.
Critical Materials	Metal microwires; metal-coated fibers.
Unique Test, Production, Inspection Equipment	Aerosol test chambers; transmissometers; test ranges; nephelometers.
Unique Software	Obscurant modeling.
Major Commercial Applications	None identified.
Affordability Issues	Inexpensive, especially in relation to the assets that are protected.
Export Control References	WA ML 4; USML XXI.

BACKGROUND

Obscurants can be identified by their impact on the electromagnetic spectrum, for example, on ultraviolet (UV), visible, IR, millimeter wave (mmW), centimeter wave (cmW), above cmW, and multispectral wavelengths. This data sheet covers those that scatter energy in the millimeter wavelength.

MCTL DATA SHEET 5.3-3. MILLIMETER WAVE—ABSORBING

Critical Technology Parameter(s)	Ext_{mm} >2; packing density >50% of the material density; dissemination efficiency >50% of the packaged material.
Critical Materials	Carbon fiber; conductive polymers.
Unique Test, Production, Inspection Equipment	Aerosol test chambers; transmissometers; test ranges; nephelometers.
Unique Software	Obscurant modeling.
Major Commercial Applications	None identified.
Affordability Issues	Inexpensive, especially in relation to the assets that are protected.
Export Control References	WA ML 4; USML XXI.

BACKGROUND

Obscurants can be identified by their impact on the electromagnetic spectrum, for example, on ultraviolet (UV), visible, IR, millimeter wave (mmW), centimeter wave (cmW), above cmW, and multispectral wavelengths. This data sheet covers those that absorb energy in the millimeter wavelength.

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