6

Tracking the Locations and Time-Activity Budgets of Deployed Military Personnel

Various methods used to track and describe the locations and time-activity budgets of the general population could also be used for tracking deployed military personnel, including subpopulations of individuals at higher risk of exposure to harmful agents. However, each method has capabilities and limitations that must be evaluated in terms of assessing life-threatening exposures to CB agents or industrial chemical stockpiles and of quantifying low-level exposures to CB agents and environmental contaminants for the purposes of current and retrospective exposure assessments and health and medical surveillance.

ACTIVITY PATTERN DATA

Exposure to an air pollutant in a specific environment is defined as the product of the concentration of the pollutant and the time (duration) an individual spends in that environment (Duan, 1982; Ott, 1982). Thus, the length of time an individual is in contact with the pollutant is as important for estimating exposure and risk as the pollutant air concentration. For dermal exposures, the duration of skin contact is as important as the concentration of the pollutant in the air or water that contacts the skin. Consequently, accurate data on the time individuals spend in specific locations and their activities during the day are critical to accurate exposure assessments. Time-activity pattern data and associated data from questionnaires can be used in three ways:

- as input data in exposure models for time spent in different

TABLE 6-1 Time Spent in Major Locations by U.S. Adults over 17 Years of Age

Location	Percentage of Time
Indoors at home	68%
Indoors not at home	19%
Outdoors	7%
Enclosed transit	6%

Source: Klepeis et al., 1996.

locations or environments (Johnson, 1995; Koontz et al., 1998; Ott et al., 1988)
- to identify the extent of close, personal proximity to sources of environmental contaminants, which can yield evidence of significantly greater exposures than environmental measurements and general population time-activity data (McBride et al., 1997; Ott et al., 1997); ideally, exposure models should use proximity data for exposure estimates
- to provide information on physical activity levels to improve estimates of pollutant intake, such as inhalation rates (Adams, 1993; EPA, 1997; Koontz et al., 1998; Layton, 1993)

Several major studies of activity patterns in civilian populations have been conducted in the last decade for estimating exposures to pollutants (Jenkins et al., 1992; Klepeis et al., 1996; Wiley et al., 1991a, 1991b). However, because of significant differences between the activities of deployed military personnel and the civilian population, much of the information collected on the general population cannot be used for exposure estimates for deployed troops. For example, as shown in Table 6-1, American adults over 17 years of age spend an average of 87 percent of their 24-hour day indoors and only a small amount of their time outdoors. Based on the duties of deployed troops and the nature of most deployments, most deployed personnel spend a much greater portion of their time outdoors. They also spend somewhat less time eating and sleeping and more time working. Thus, data specific to deployed personnel will be necessary for accurate estimates of exposures.

METHODS OF OBTAINING TIME-ACTIVITY DATA

A complete characterization of an exposure requires knowledge of the person's location and activity, both in terms of the geographical location and of the microenvironment at that location (outside or inside a vehicle, building, etc.). Geographical location can be obtained from GPS, but data on the microenvironment requires other methods, such as activity diaries or logs, questionnaires, videotaping, or observation. These methods provide both real-time and retrospective information. Prospective questionnaires can also be used for specific purposes. Technologies such as GPS (Battelle Memorial Institute, 1997, 1999; Brauer et al., 1999; Maszle, 1998; Spear, 1998), the total isolated by microenvironment exposure (TIME) monitor (Moschandreas et al., 1993, 1994), and various motion sensors and data loggers (Brauer et al., 1999; Haskell et al., 1993; Pate, 1993; Schutz and Chambaz, 1997; Waldman et al., 1993) have been used increasingly in recent years to record or substantiate specific types of activity/location information for exposure research, as well as to record real-time data on a user's usual activities. All of these methods could be used to improve exposure estimates for deployed military personnel.

Time-activity methods were used in occupational health studies as early as the 1970s. However, despite the increased collection of time-activity data in exposure and health studies, the science of this field is still relatively young. Methods are still being developed, and no guidelines or standards for collecting and using data in exposure assessments have been widely accepted. The EPA has developed general exposure assessment guidelines (EPA, 1992b) and the *Exposure Factors Handbook* (EPA, 1996b) that provide general guidelines. However, no activity-pattern methodology is considered ideal, and the methods of choice are dictated by the specific data required, the application for which they are intended, the funds available, and the capabilities and characteristics of the subject population.

Global Positioning System

GPS is a satellite-based system that provides worldwide, continuous position, velocity, time, and related data to civil and military users. GPS has a large and growing number of applications in the fields of marine, land, and aerospace navigation and precise time and time transfer. These applications include nearly all uses of position, velocity, and precise time, such as in surveying, geodesy and mapping, precision farming, air traffic control, asset location and tracking, timing of communication systems and power grids, and many other civil and military uses.

GPS has a number of different modes of operation, each with its own performance capabilities. First, GPS can be used autonomously (on a stand-alone basis). In this case, the user equipment receives and uses only the signals from the constellation of spacecraft to determine user position, velocity, time, and related parameters.

GPS can also be used in a differential mode in which known navigation data at a reference point and time are compared with GPS measured data at the same point and time. The corrections from this process are then applied to the GPS measured data taken at a remote point. For real-time operation, a data link between the reference receiver and the remote receiver is normally used to communicate the corrections. This process has the great advantage of canceling the fixed (bias) measurement errors that have the same effect on both locations. The differential correction technique, which other navigation systems have also used to improve performance, performs well with GPS. The differential corrections can be used immediately or stored and used later with postprocessing methods.

Although GPS has performed extremely well and has generally exceeded expectations, some significant improvements can be made. A number of committees representing both government and civil communities have investigated the system's deficiencies over the past decade to determine the capabilities and features of a future GPS that would meet the needs of military and civilian users (McDonald, 1998).

GPS has been used in several recent exposure and activity studies (Battelle Memorial Institute, 1997, 1999; Brauer et al., 1999; Maszle, 1998; Spear, 1998) and can provide very useful information on the exact location of an individual, a unit, or a vehicle. Civilian GPS devices have consistently decreased in size and price over recent years, and are expected to be available in a small, lightweight wristwatch style the next year (McDonald, 1998).

The baseline GPS constellation consists of four spacecraft (and occasionally more) in each of six equally-spaced orbit planes. The spacecraft are at an altitude of 10,898 nautical miles (20,180 km) above the earth. The nearly circular GPS orbits are inclined at about 55 degrees to the equatorial plane providing users continuous worldwide access (if unobstructed) of between 6 and 12 GPS spacecraft.

DoD has also contracted to purchase the first group of a planned purchase of 33 fourth-generation, follow-on GPS spacecraft planned for replacement of the replenishment spacecraft. These 33 spacecraft will carry the GPS constellation well beyond 2010. The four generations of spacecraft are: I (developmental); II-IIA (current operational); IIR (replenishment); and IIF (follow-on). A summary of the basic GPS operating characteristics is given in Table 6-2.

Activity Diaries and Logs

Many different types of diaries and logs have been used to obtain activity and location data for exposure assessments. Typically, diaries and logs are in written form, but they may also be recorded directly into

TABLE 6-2 Expected Evolution of GPS Performance

	GPS Bands					Position	
	RNSS		ARNS		Diff.		
Mode of Operation (M or P/Y-code)	L1[a]	L2[a]	L3c[b]	SA	GPS	2000	2010
Conventional civil stand-alone SPS: C/A-code	<			≤		50–100 m	5–25 m
Code Differential SPS: C/A-code					<	1–5 m	30 cm–1m
Real time Kinematic (RTK) SPS: C/A-code, carrier phase meas.				≤	<	10–50 cm	3–20 cm
Survey: Post processing; long b. SPS: C/A and carrier phase (with 2f)	<	<		≤	<	0.5–10 cm	0.1–3 cm
Conventional civil stand-alone SPS: C/A-codes	<	<				NA	3–6m
Code differential *SPS: C/A-codes	<	<			<	NA	30 cm–1m
Precision stand-alone 2000 *SPS: C/A, & F-codes (10.23 Mcps)	<	<	<			NA	1–3 m
Real time Kinematic (RTK) *SPS: C/A C 10, carriers Φ meas.	<	<	<		<	NA	1–10 cm
Precision attitude measurement *SPS: C/A & F (10.23)—codes, carriers	<	<	<		< <	1 m radian 0.2 m rad	NA
Military receiver (1f) PPS C/A+P/Y or M-code	<<	<<				5–25m	3–20m
Military receiver PPS C/A+P/Y or M-codes	<<	<<				4m	0.5–1m
Military DGPS receiver PPS C/A+P/Y or M-codes	<<	<<			<	1m	20–50 cm

[a] Civil codes in 2010: L1, L2 (L2c) are C/A-codes.
[b] L3c assumed to be new F-code at 10.23. Mbps.

Note: Accuracy estimates for 95 percent confidence in horizontal; vertical accuracy is about 2.4 × horizontal dimension.

Source: McDonald, 1998.

Velocity		Time		
2000	2010	2000	2010	Comments
15–30 cm/s	10–20 cm/s	170–350 ns	40–100 ns	Iono dependent No SA in 2010
10–20 cm/s	3–10 cm/s	30–60 ns	20–30 ns	Iono dependent No SA in 2010
5–10 cm/s	1–5 cm/s	NA	NA	Iono dependent No SA: short b
NA	NA	NA	NA	L2 carr Φ in 2000 Baseline (b) dep.
NA	10–20 cm/s	NA	40 ns	No L2c in 2000
NA	5–10 cm/s	NA	20 ns	No L2c, in 2000
NA	2–10 cm/s	NA	10 ns	No L2c, L3c in
NA	0.5–3 cm/s	NA	NA	No L2c, L3c in 2000
NA	NA	NA	NA	No L2c, L3c in 2000
				Attitude, angle Θ
0.1 m/s	0.05 m/s	100 ns	40 ns	E.g., PLGR (P/Y) Iono dependent
0.1 m/s	0.05 m/s	80 ns	25 ns	Std. 2f rec-(P/Y) Future 2f rec-(M)
5 cm/s	2 cm/s	50 ns	10 ns	Diff. GPS 2f rec S/C, alt. DL msg

an electronic data logger (e.g., a small device like the personal information carrier[1] [PIC] being developed by the Army) at specified intervals or into a computer file; the data entry can be performed manually or automatically. Diaries and logs can contain either current or retrospective data. For a more detailed discussion of the PIC and other major medical information systems, see reports by DoD (1999b), the Institute of Medicine (IOM, 1999), and the National Science and Technology Council (1998).

Written/Hard Copy Forms

Hard copy diaries or logs are typically carried by a subject throughout the period of interest, usually a day or more, and entries are made either with each major change of location or activity or at specified intervals, such as every hour. Alternatively, they may be filled in at the end of the study period (such as at night or within 24 to 48 hours following the period of interest) by recall either by the subject alone or in conjunction with an interviewer; 24- to 48-hour recall has been found to be relatively accurate (Freeman et al., 1991; Robinson, 1985), particularly when the entire day is covered in sequence. Self-reported diaries (filled in by the subjects without assistance from an interviewer) are common but have been found to be somewhat less accurate than interviews, especially for males. Females appear to provide more detailed and more accurate information in self-reported diaries (Stock and Morandi, 1989).

Quality control is achieved by pretesting the diary or log instrument with a few members of the subject population (i.e., a focus group) and through careful explanation of how the diaries or logs should be filled in. Careful review of the completed diary or log by a technician or interviewer also helps to ensure that no data are missing and allows for corrections.

The major advantages of hard copy diaries are that they are usable by anyone who can read and write, they are generally economical, and they can be used as backup files once responses have been entered into a data file. Disadvantages include the time and cost of coding and entering the data into computer files, errors due to misunderstanding of directions or undisclosed illiteracy problems, and incorrect coding and transfer of information from the diary to the computer file by the data management technician. Another disadvantage is the potential breach of security if diaries were to fall into enemy hands.

[1] The PIC is a matchbook-sized flash memory card that can be worn around the neck (like the former "dog tags") to store personal identification and medical data (DoD, 1999c; Investor's Business Daily, September 29, 1999; IOM, 1999).

Electronic/Computerized Diary and Logging Methods

Electronic or computerized diary or log data recording has several advantages over hard copy methods but may not always be suitable. Electronic methods eliminate the need for the coding and transfer of hard copy responses to a computer file. However, electronic methods can only be used for study populations that are comfortable with technological devices or studies in which interviewers or technicians enter the data. Also, if the electronic device malfunctions, all of the data for that participant may be lost.

Data Loggers

Data loggers are electronic devices used to record a person's activities. Typically, a limited number of activities and locations must be preprogrammed into the device, which limits the amount of detailed information that can be obtained by the investigator. Data loggers are most suitable for cooperative, technologically comfortable populations and studies that require only basic, limited data or gross estimates of time spent on major activities and locations. Because of early problems with malfunctioning devices, data loss, and practical problems, most investigators have chosen to rely on hard copy diaries. With recent advances in palm-sized data loggers and GPS technology, researchers have begun to re-evaluate their usefulness for exposure studies (Akland, personal communication) and have begun to use them more in field research (Brauer et al., 1999; Cohen and Cotey, 1997; Haskew et al., 1995; Wilkins et al., 1997).

TIME Sensor

One electronic monitor still being refined that may be of use to the military in the future in a modified form is the TIME (total isolated microenvironment exposure) monitor, a personal sampling device that has several capabilities designed to measure microenvironmental exposures to VOCs in four primary microenvironments (Moschandreas et al., 1993, 1994). One component, a "shadow sensor," identifies and records the user's location every 30 seconds in one of four categories: indoors nonoccupational; indoors occupational; outdoors; and inside a vehicle (in transit). The device uses an ultrasound transducer and electronic logging package to measure the vertical distance from the device to any obstruction or "ceiling" above it and interprets and records the data accordingly. Distances of more than 11 feet are interpreted to mean the user is outdoors; distances of 4 to 11 feet are considered indoors; and distances of less than 4 feet are logged to indicate that the user is inside a car, bus, train, or other vehicle. To differentiate indoor occupational from indoor nonoccupational locations, the respondent must press a button upon entry to each indoor environment (the device sounds a reminder chime upon entry into an indoor location).

The second component of TIME determines the path of air to be sampled and the sampling rate, based on the location identified. The third component is the sampling system, which consists of four cartridges or tubes corresponding to the four microenvironments. The electronic sensor opens the valve to the correct cartridge for the current environment, and air is drawn through the carbon-based, multisorbent beds in the tube at a predetermined rate. The sample is later analyzed by gas chromatography to provide information on the individual's exposure levels of 42 VOCs in the four environments. The TIME monitor weighs about 1.6 pounds and measures about 7 x 4 x 1.5 inches.

TIME has been field tested and found to provide accurate estimates of time spent in the four major locations (with differences of only a few percent compared to data collected by other means), as well as improved measures of personal exposures over those determined by other measurement and modeling approaches (Moschandreas et al., 1994). TIME could be refined to meet specific needs and applications for deployed military personnel (Moschandreas, personal communication).

Questionnaires

Questionnaires are commonly used as adjuncts to diaries or activity logs to obtain data on specific activities that may involve the use of, or close exposure to, potential contaminant sources. Questionnaires are also used to obtain information on socioeconomic and demographic characteristics and household and building factors, such as heating sources and types of structures. They are also used to elicit specific data on the use of known sources of a particular pollutant of interest (for example, all indoor sources known to emit fine particles) and to elicit retrospective or historical exposure-related data, such as occupational histories and exposures. Questionnaires can also be used to obtain current information for use in prospective studies.

A number of quality control issues are associated with the development and administration of questionnaires and the interpretation of results, but these are reasonably well known and can be addressed by accepted methods (NRC, 1991a; Visscher et al., 1989). For example, the wording of questions, and even the order in which they are presented, can be critical factors in obtaining accurate data. For this reason, questionnaires must be pilot tested by a focus group of individuals similar to, or selected from, the intended subjects. Problems with nonresponse and noncompliance are common with questionnaires administered to the general population or a population that is reluctant to be studied. Although noncompliance and nonresponse will probably be minimal problems in a military setting, steps should be taken to maximize the number of responses. Simple instructions, rapid follow-up, various types of incentives, and other methods have been used successfully to elicit complete responses and ensure a high response rate.

Videotaping

Videotaping has only recently been used in exposure assessment studies to study children's behaviors. Videotaping may have some limited use in special situations during deployment (e.g., to monitor the perimeter of known enemy chemical agent storage facilities).

Observers

Human observers have also been used to record human activities for exposure studies. This process suffers from some of the same disadvantages as videotaping—the subjects may change their behavior under observation, and the added expense and effort may not be justified. Human observers are useful for verifying certain activities of interest, especially those that are done frequently or in a specific location. For example, observers have been used to measure the time individuals spend filling their gas tanks at gas stations to estimate the duration of elevated exposures to volatile gasoline components (Colome et al., 1992; Wilson et al., 1993). Human observers may have some limited value during deployment.

Other Methods of Tracking Activities

Several other types of devices have been used to measure one or more aspects of people's activities and movements. For example, motion sensors have recently been used with personal air samplers to verify that a subject is wearing the sampler as agreed (Rodes et al., 1995, 1996). The data collected are correlated with the diary data to confirm the time periods when the sampler was worn as a quality control measure. Because monitors detect any motion, they can also provide an accurate measurement of the time individuals are resting or immobile and the time they are active at any level. This information can be used as a general confirmation of estimated inhalation rates for an individual by confirming the number of hours spent at rest.

FACTORS THAT DETERMINE HUMAN ACTIVITIES AND LOCATIONS

The activity patterns of any defined human population vary greatly. Capturing that variability requires that the primary determinants of the activities of individuals within the population of interest be identified and that studies be designed to obtain sufficient, preferably representative, data on these activities. For the general U.S. population, the following major factors determine people's activities, locations, and to some extent, their exposures to pollutants: age, gender, occupation, socioeconomic status, season of the year and day of the week, and geographic region or country. For deployed military personnel, the strong determinants of activities and movements from one location to another are very different. These factors would most likely include: the purpose of deployment (major theater war vs. noncombat small-scale contingency mission); occupation, duties, and rank of unit, squad, and individual; country and locale of deployment (e.g., desert or jungle); and branch of service (air, land, sea).

A baseline study of activity and location-time budgets of a sample of deployed military personnel could provide enough information to identify the relative significance of these and other factors as determinants of deployed troops' exposures to environmental pollutants and indirect (noninhalation) exposures to CB warfare agents. Once sufficient data have been obtained and the major factors identified and/or confirmed, subgroups at higher risk can be more easily identified and should become the focus of subsequent studies.

However, the assumption that a time-activity budget of deployed personnel is representative could be misleading. The duties and activities of different specialists require that subpopulations who have roughly similar work environments be identified. Any study of time-activity budgets of military personnel should be based on random sampling that provides representative samples of the specific population or subpopulation of interest. Random sampling provides a way of constructing a representative sample of the population of interest, at least for the factors most likely to determine exposures.

EVALUATION OF CURRENT AND EMERGING TRACKING METHODS

DoD has two purposes for obtaining tracking data: (1) averting immediate threats from acute exposure to CB agents and accidental releases; and (2) estimating long-term exposures to low levels of environmental pollutants and CB agents. In evaluating the utility of methods for tracking activities and locations of deployed personnel, DoD should consider the following factors:

- the relative utility or value of the data that would be obtained for (1) the prevention of acute exposures, (2) the prevention of long-term exposures, and (3) the retrospective estimates of low-level exposures during deployment, particularly for CB agents and environmental pollutants
- the burden placed on individuals in terms of the size and weight of tracking devices that must be carried; the time required for record keeping/participation; and security issues
- data management issues, including costs, feasibility and ease of transmission, storage, handling, retrieval, and analysis

Preventing Acute Exposures

Any activity/location-tracking method that provides early warning of possible CB agent contact will be valuable to deployed personnel. Because of recent advances in miniaturization and accuracy, GPS appears to be an obvious choice for providing rapid information on the location of units, squads, and even individual soldiers. In the next year, civilian GPS devices may be miniaturized to wristwatch size (McDonald, 1998). Comparable miniaturization of military GPS devices would reduce the burden on users and allow individual soldiers to use and benefit from GPS. Combined with a miniaturized data logger, GPS could provide activity/location information useful for preventing acute exposures, as well as for estimating long-term exposure.

In a deployed military setting, miniaturized video cameras in unmanned aerial vehicles could be used to confirm the presence or absence of personnel in high-risk locations or to estimate the time spent conducting high-exposure activities. Assuming that the video could be securely transmitted to the commander's staff or command center, unmanned aerial vehicles could facilitate timely warnings to personnel at high risk of exposure to CB attacks or accidental releases. The value of information would be high, and the burden on individual soldiers would be low.

In general, diaries, logs, and questionnaires would not be directly relevant to improving the military's ability to identify and prevent possible exposures to imminent threats, such as CB warfare agents or industrial accidents.

Estimating Long-Term Exposures

DoD must have representative, baseline data on the activity and location-time budgets of the subpopulations of deployed troops. These data could be used to identify groups and individuals at higher risk of exposure either to industrial or environmental toxins for conducting retrospective exposure assessments to all types of harmful agents. At a minimum, these data would provide much-needed information on time spent indoors, outdoors, and in enclosed transport vehicles by various categories of deployed military personnel.

Not every individual has to be studied. Either a sufficiently large sample could be selected randomly from an entire population of deployed personnel, or a representative sample could be selected of cohorts (groups) based on the major factors indicated above (e.g., purpose of deployment, occupation/duties, etc.). The latter approach, which is essentially a stratified sample approach with random selection within strata, would probably yield data most immediately useful because units believed to be at higher risk could be studied first. Data for long-term exposure assessments should be collected for periods of several days and, where relevant, in all four seasons.

Written or electronic diaries completed at the end of the day or at the end of a "shift" provide the most feasible approach to obtaining data in the near term because they are currently available. A hard copy diary that provides basic activity and location information could be completed by each subject in 10 to 15 minutes per day. A more detailed electronic diary and questionnaire, such as one administered by an interviewer, could take up to 45 minutes per day. However, electronic data are immediately coded as they are input by the interviewer, eliminating the need for subsequent coding.

The most promising automated approach for obtaining data for estimates of long-term exposures of troops to low levels of environmental pollutants and warfare agents appears to be the selected use of a modified TIME device or similar data logger in conjunction with GPS. The TIME device provides the core information most critical to exposure estimates—the geographic location of an individual or unit across time and estimates of the time spent indoors, outdoors, and in transport vehicles. Initially, perhaps, one soldier per platoon or company should carry paired units; eventually, as miniaturization advances, more individuals could be provided with such units. The small group of individuals should be carefully chosen to ensure that they are representative of the larger group.

DoD should consider two options for using the TIME device. First, a much smaller, lighter device could be developed that records only the location of the user and does not record any pollutant data. (Data on exposure to VOCs could be more easily obtained by passive badges, which are lighter and more feasible in a military setting than the active air-sampling portion of the current TIME device.) A second option would be to use the current TIME device with a reduced pollutant monitoring capability (one tube instead of four) to obtain a single 24-hour air sample in conjunction with the location data. The device could be worn by one individual per unit to measure exposures to many VOCs. This would provide accurate baseline data on actual exposures of various military groups to toxic environmental and occupational VOCs.

As a near-term alternative to the TIME device, a palm-sized data recorder could be used in conjunction with a GPS locator to record both the geographic location of the user (and the user's unit) and time spent in specific environments. The advantages of palm-sized recorders over the TIME device are that some commercially available palm-sized recorders appear to be more readily compatible with GPS than TIME, and they can be programmed for entry of data on the user's activities in addition to information on the major locations visited. The main advantage of the TIME monitor is that it records location automatically.

FINDINGS AND RECOMMENDATIONS

Finding. GPS is a critical component of an effective system for predicting and preventing exposures to CB agents, including accidental agent releases. Currently, only one individual per unit or squad carries a GPS receiver. Once GPS devices have been miniaturized and militarized, each individual could carry one. The location of each individual and the individual's proximity to identified or suspected releases of CB agents could then be identified, and orders for preventive actions could be directed to the individuals at greatest risk.

Recommendation. The Department of Defense should continue to support the development of miniature (e.g., wristwatch style) military global positioning system receivers. Given current technology, these could be fielded within five years. The decision to equip every deployed unit or individual with a GPS-based receiver should be based on the results of trade-off analyses.

Finding. A miniaturized, multifunctional device that can detect CB agents and TICs, determine location and time, and record the data would be extremely valuable both for protecting deployed troops and for analyzing past exposures. These devices could detect threats from harmful substances, locate the wearer in time and space, and store the data until it could be downloaded. There are, of course, many technical challenges (e.g., size, weight, power requirements) to achieving this capability. Very small devices already exist, however, that can partly meet these goals. The Army's MIST Program, for example, uses a passive sampler no thicker than a common adhesive bandage and less than one inch square. On balance, establishment of a goal to develop these devices would offer, at a minimum, a valuable target for researchers and developers.

Recommendation. The Department of Defense should support the goal of developing a miniaturized, multifunctional device for detecting agents, determining location, and storing data.

Finding. Individuals may have performed jobs prior to or during their deployment that involved higher-than-average or longer-than-average exposures to toxic pollutants. Predeployment information could be used to identify individuals whose prior exposures put them at higher risk from additional exposures during deployment, as well as to identify possible prior exposures to harmful agents that otherwise might be believed to have occurred during deployment. The postdeployment information would provide a concise record of major duties performed and the use of, or proximity to, possible or confirmed sources of pollutants.

Recommendation. The Department of Defense should implement measures to identify individuals whose predeployment exposures might put them at higher risk of harm from additional exposures during deployment. The information should include major duties performed and the use of, or proximity to, possible or confirmed sources of pollutants during deployment.