INEL/CON-97-00091
CONF-9705185--

MOBILE MUNITIONS ASSESSMENT SYSTEM DESIGN, TESTING, OPERATIONAL EXPERIENCE

Kenneth D. Watts and Alan M. Snyder
Idaho National Engineering Laboratory
P.O. Box 1625
Idaho Falls, Idaho 83415-3840
Telephone: (208) 526-9628

Leonard C. Rowe
U.S. Army PM CML DEMIL
ATTN: SFAE-CD-NP (L. Rowe)
Aberdeen Proving Ground, MD 21010-5401
Telephone: (410) 671-1094

ABSTRACT

The remnants of America's chemical weapons program exist at more than 200 sites in the United States. The U. S. Army's Project Manager for Non-stockpile Chemical Materiel (PMNSCM) has the responsibility for the remediation of non-stockpile chemical warfare materiel (CWM). PMNSCM must respond to a variety of situations involving discovered, recovered or buried materiel. This response requires unique hardware capabilities to characterize, assess, and provide information to develop plans for disposing of the materiel.

PMNSCM sponsored the development of a Mobile Munitions Assessment System (MMAS) at the Idaho National Engineering and Environmental Laboratory (INEEL) to meet the need to characterize and assess non-stockpile chemical warfare materiel. The MMAS equipment is capable of distinguishing CWM from conventional munitions, identifying the agent fill and level, and assessing the status of the firing train. The MMAS has a data processing, collection, and storage subsystem and a communications link to a Dugway Proving Ground (DPG) database. A typical data package includes X-rays, elemental spectra, weather data, physical descriptions, photographs, video, etc. The MMAS data will be used by the Army's Munition Assessment and Review Board (MARB) to help determine the appropriate methods and safeguards necessary to store, transport, and dispose of non-stockpile CWM.

The first MMAS prototype will be used by the Army's Technical Escort Unit (TEU) to rapidly respond to chemical munitions that are discovered/recovered throughout the United States. The design of the first prototype is complete and is described. The testing of the first prototype started with a road worthiness test. This test was conducted on an interstate highway and city streets between the INEEL and Hill Air Force Base (HAFB), Utah. At HAFB, the MMAS was loaded onto a C-130 aircraft hull to determine fit and to evaluate tie down locations. Later tests included road worthiness tests over state, county, secondary, and back roads. The prototype underwent qualification testing at DPG from January through March 1997. The testing included operations at bunkers and remote locations. Typical recovery and assessment operations were conducted using munitions filled with known agent and simulant fills. The qualification testing is discussed in detail.

The MMAS Phase I prototype has performed extremely well during the road testing, load testing, and field qualification testing. The system is currently being used by the Army's Technical Escort Detachment at DPG to gain more operational experience and will later be transferred to Aberdeen Proving Ground, MD, for TEU.

BACKGROUND

The Mobile Munitions Assessment System (MMAS) is being developed for use in the characterization and assessment of chemical

DISTRIBUTION OF THIS DOCUMENT IS UNLIMITED

MASTER

DISCLAIMER

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, nor any of their employees, make any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

DISCLAIMER

Portions of this document may be illegible in electronic image products. Images are produced from the best available original document.

warfare materiel (CWM). The United States has developed, stored, and tested CWM for several decades. The remnants of these activities have resulted in the presence of suspect CWM at more than 200 sites in the United States, the District of Columbia, and the U.S. Virgin Islands. Public Law 99-145 directed the Department of Defense (DOD) to destroy this CWM, and House Appropriations Report 101-822 directed the Secretary of Defense to organize a program so all DOD chemical warfare destruction activities rest within a single organization. On March 13, 1991, the Secretary of Defense designated the Secretary of the Army as the DOD executive agent for the destruction of all CWM. The Army established the U.S. Army Program Manager for Chemical Demilitarization (PM-CD) on October 1, 1992. Two projects were established within PM-CD; one for stockpile chemical materiel and the other for non-stockpile chemical materiel. The Project Manager for Non-stockpile Chemical Materiel (PMNSCM) was established to execute the project related to the destruction of non-stockpile chemical materiel.

This materiel is divided into five categories that reflect the broad range of materiel histories. These categories are recovered CWM, binary chemical weapons, miscellaneous CWM, former chemical weapon production facilities, and buried CWM.

During CWM recovery operations, filled containers and munitions of unknown identity may be discovered, which due to degradation of their exterior or lack of documentation, may be difficult to characterize immediately. Identification may be further complicated with the presence of nonmilitary hazardous materials on the same site. It may not be known if these recovered munitions and containers contain conventional explosives, chemical agents, or incendiaries; if the munitions are fused, unfused, armed, partially armed, or unarmed; or if the munitions are in mint condition, internally degraded, or in severely degraded condition. Information on the identity, contents, and condition of these recovered items must be obtained before operations can safely continue. The role of the MMAS is to collect this information.

INTRODUCTION

The INEEL is supporting the MMAS activity as a "Work For Others" (WFO) project funded by the PMNSCM. Phase I of the MMAS, referred to as the Initial Response System, will involve the rapid development of an assessment system consisting of immediately available technologies. The Phase I system consists of a vehicle which houses a number of nondestructive evaluation (NDE) components and other subsystems including a radiography (X-ray) system, Portable Isotopic Neutron Spectroscopy (PINS) system, data acquisition and handling system, communications system, air monitors, meteorological station, agent detection equipment, and audio/video equipment.

The MMAS was jointly developed by engineers at the INEEL and at Dugway Proving Ground (DPG). The design and fabrication was completed in 12 months (January 1996 to December 1996), and the testing started in January 1997.

To verify that the MMAS met the design and functional requirements, testing of the system was conducted in three stages: first, component/subsystem testing was conducted during assembly of the MMAS; second, system-level testing where the entire Phase I MMAS was used to conduct tests on surrogates and verify system operation; and finally, a field testing program where the Phase I MMAS was used to examine both surrogates and munitions at DPG, UT. The following list identifies the

DPG field testing and validation efforts that have been identified and completed:

1) DPG Field Test #1 - used the MMAS to inspect and identify known and unknown munition surrogates.
2) DPG Field Test #2 - used the MMAS to inspect and identify known agent-filled munitions located in "igloos" (i.e. bunkers) at DPG.
3) DPG Field Test #3 - used the MMAS to inspect and identify unknown munition surrogates in the field.

All activities associated with the MMAS DPG field tests were performed primarily by the U.S. Army's Technical Escort Unit (TEU). In particular, any activity involving the use of actual, agent-filled munitions must be performed by TEU personnel. INEEL and nonmilitary DPG personnel observed the tests and were available for consultation and support before, during, and after the test.

A "system retrofit" was incorporated into the schedule between the first and second DPG field test. This allowed system modifications to be made prior to the start of the final assessment tests using munitions or surrogates placed in the field. A complete inspection of all MMAS components, subsystems, and systems was performed by the INEEL MMAS team following each field test to verify continued function and operability.

The testing demonstrated that TEU could deploy the MMAS at a discovery site and be ready for operations in less than 30 minutes.

DESIGN DESCRIPTION

The MMAS is a self-contained system consisting of a one-ton, four-wheel drive, crew cab truck with a 24-foot, tandem axle, fifth-wheel trailer designed to house various NDE subsystems and support equipment. The trailer is designed with an air-ride suspension to reduce the shock and vibration loads imparted to the equipment it carries. The MMAS is designed to be transportable over land via either roadways (as shown in Figure 1) or rail and by air on board standard military cargo aircraft.

Figure 1. MMAS truck and trailer being driven on gravel roadway during testing.

Several, immediately available, technologies for the nonintrusive characterization and assessment of recovered CWM are included in the MMAS; a Portable Isotopic Neutron Spectroscopy (PINS) system, radiography (X-ray) systems, data acquisition and handling system, chemical monitors, meteorological stations, communication systems, and audio/video equipment. The PINS system includes a gamma-ray spectrometer with a dedicated 50-liter liquid nitrogen supply, a Nomad Plus® multichannel analyzer, a californium neutron source with shielding, interconnecting cables and a notebook computer. Figure 2 shows the PINS system being used in the field by the U. S. Army's elite TEU.

The radiography systems include two X-ray generators (150 keV and 300 keV) and two controller subsystems. The 150 keV radiography system (a SAIC RTR-3 unit) is a near-real time system with a computer-based

Figure 2. PINS system being used by TEU personnel.

imaging system included. Figure 3 shows the 300 keV system (an ANDREX Smart 300 unit) being used by TEU personnel. The ANDREX system uses a film processing subsystem that can develop either Polaroid-type radiographic film or regular "negative" X-ray type film. A light table is installed in the trailer for viewing of developed X-ray film, and a digital scanning camera is used to grab the radiograph image and store it in the MMAS computer system.

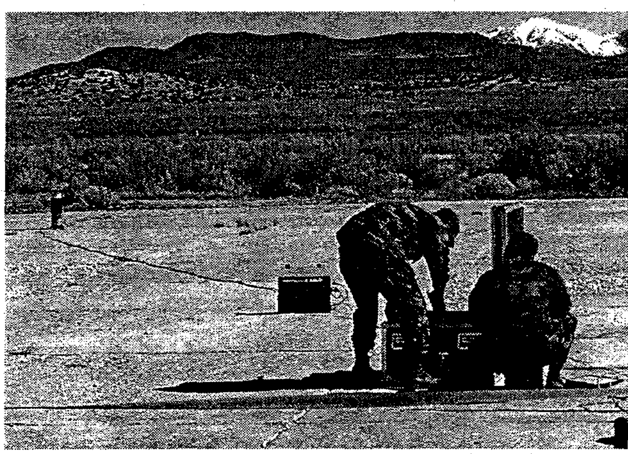

Figure 3. ANDREX radiography system being used by TEU personnel.

The MMAS data acquisition and handling system is used primarily for system operations and temporary collection and storage of data from the NDE subsystems and other systems used within the MMAS. Data is collected by the various MMAS systems (PINS, radiography, meteorology, etc.) utilizing their own data acquisition hardware and software. The data is then downloaded to the MMAS data acquisition and handling system for storage, manipulation, and transmission to other locations. This transfer requires hardware and software compatibility, and it allows assessment data to be relayed to "experts" for review and analysis. The MMAS data acquisition and handling system also includes a library of information about the munitions the MMAS is expected to encounter. Two primary computer systems (networked together) are provided for redundancy and backup purposes (see Figure 4). Each system is PC-based with significant random access memory (RAM), hard disk storage space, and processing speed. An ink jet printer is supplied with the system.

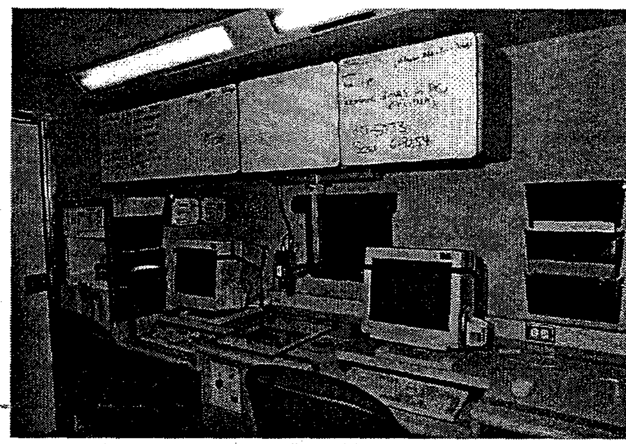

Figure 4. MMAS computer systems.

Three Environics Oy M-90 Chemical Warfare Agent Detectors are included with the MMAS to provide detection of both surety (chemical agent) and non-surety chemicals that may be found in the air at a remediation site. The M-90s (shown in Figure 5) include real-time displays that can be monitored by the operators working at the remediation site.

The MMAS includes two, simple, self-contained meteorological stations with deployable masts of two meters and 10 meters

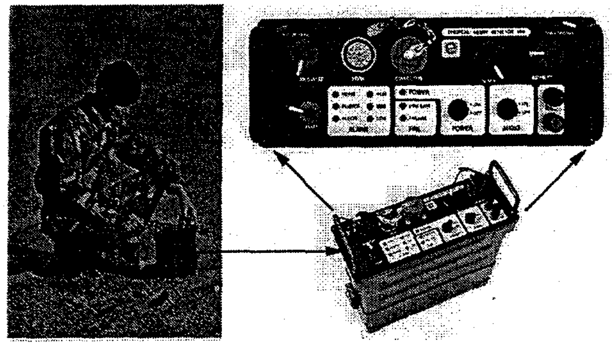

Figure 5. M-90 Chemical Warfare Agent Detector

to obtain information on the current atmospheric conditions at the incident site. These stations provide information on wind speed, wind direction, air temperature, and atmospheric pressure. This information is needed for dispersion predictions used to evaluate the threat posed by an uncontrolled chemical release during the munitions recovery activity. The two-meter mast is deployed in the field away from the trailer (see Figure 6) and the 10-meter mast is integrated into the trailer for deployment directly above the MMAS. Data from the weatherheads is fed into the MMAS computer system and is displayed on a monitor.

Figure 6. Two-meter weatherhead being deployed.

The MMAS also includes a variety of photographic and video equipment, communications equipment, and safety equipment. Included are a Polaroid® camera, 35-mm digital camera, portable Hi-8 camcorder, Hi-8 video tape player, VHS tape player and recorder, two color monitors, and a video matrix switch. Communications capabilities include cellular phones, a two-way radio system, wireless communication system for use by downrange personnel while wearing protective clothing, and an INMARSAT-B satellite uplink system. Figure 7 shows the video viewing and editing station and the communications equipment installed in the MMAS. Safety equipment includes personnel protective equipment and clothing items such as OSHA Level A clothing, commercial protective suits, gloves and boots, fire extinguishers, first aid kits, and Self-Contained Breathing Apparatus (SCBA) tanks and respirators. Figure 8 shows TEU personnel dressed in OSHA Level A Responder® suits packaging an item prior to assessment.

Figure 7. MMAS video viewing and editing center and communications center.

TESTING

To verify the MMAS met the necessary design and functional requirements, comprehensive testing was conducted in three stages: first, components and subsystems were tested during assembly of the MMAS; second, system-level testing was performed (e.g., road worthiness tests); and finally, field tests were performed

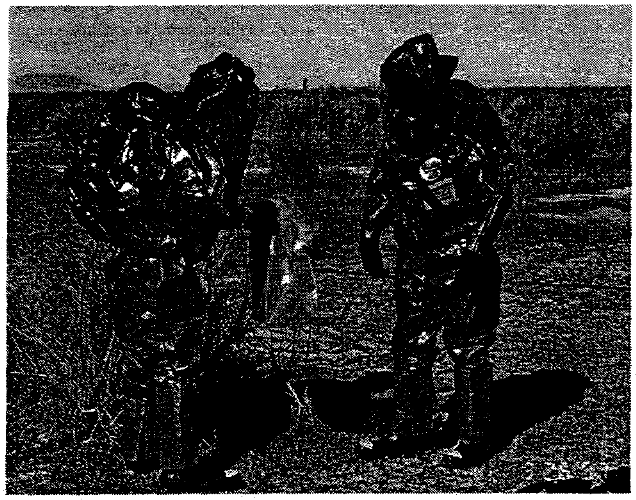

Figure 8. TEU personnel wearing OSHA Level A Responder® suits.

using MMAS to examine both surrogates and munitions at DPG, Utah. The following paragraphs briefly describe the scope and results of the MMAS testing and validation efforts.

During assembly of the MMAS Initial Response Vehicle, numerous subsystem checkout and acceptance tests of the individual components and subsystems were performed before and after installation to assure proper performance. The tests included component operation, electrical continuity checks, motor rotation checks, mechanical performance, etc. Most of these tests were conducted at the INEEL North Holmes Laboratory (NHL) in Idaho Falls. The components and subsystems requiring checkout and acceptance testing included:

- MMAS vehicle (truck/trailer).
- 15 kW and 6.5 kW power generators.
- Heating, ventilation and air conditioning (HVAC) system.
- X-ray systems.
- Portable Isotopic Neutron Spectroscopy (PINS) system.
- Chemical/air monitors.
- Explosive Ordnance Disposal (EOD) equipment.
- Weather station systems.
- Communications equipment.
- Video equipment.
- Data acquisition and handling system hardware and software.

In general, the "controlling" documents for these checkout and acceptance tests were checklists which addressed all safety precautions and data recording requirements. These subsystem-level testing activities included rigorous road worthiness tests to verify the handling and ruggedness of the MMAS under various road and weather conditions. Road tests were performed on interstate highways, gravel, secondary roads, and off-road (see Figure 9).

Figure 9. MMAS being driven off-road.

The weather conditions varied from summer (90°F and dry) to wintry conditions (15°F and snowy). The MMAS exhibited excellent handling and stability characteristics during each of the test phases. To verify that the MMAS could be airlifted on a military cargo plane, it was driven to HAFB, Utah, and successfully loaded into a fuselage of a C-130 Hercules (the smallest of the military's air cargo fleet - see Figure 10). This demonstrated that the MMAS could be loaded onto any military cargo aircraft and airlifted anywhere in the continental United States, or actually in the world.

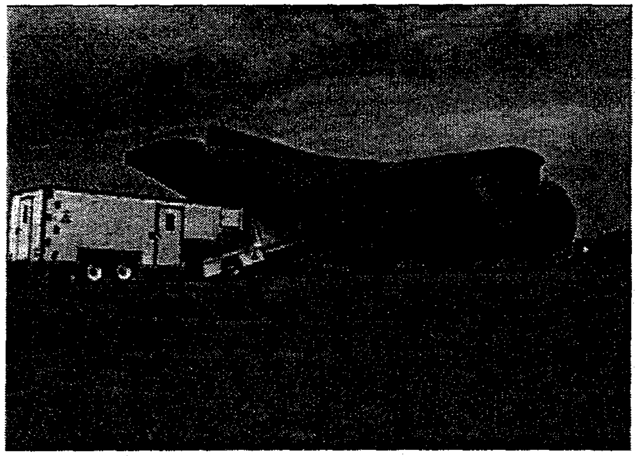

Figure 10. MMAS being loaded on C-130 fuselage at HAFB, Utah.

The first, fully integrated system-level test of the MMAS was performed as a two-day "field test" at the INEEL. This test was performed on the INEEL site (a high desert climate) using surrogate materials developed for the PINS system instead of real chemical agents. Using surrogates eliminated the hazards associated with real munitions and the approvals, training, and safety constraints that would have been imposed on the tests if real chemical agents had been used.

The primary objectives of the INEEL field test were:

1) To verify the operation of the major MMAS subsystems under actual environmental and operating conditions found in the field.
2) To use and verify the draft procedures being developed to operate the MMAS.

The operational verification tests assured the performance of the individual MMAS subsystems and the performance of the integrated system. Operating procedures were being developed for the MMAS, and this test was the first, near-real assessment situation that could be used to evaluate the adequacy of those procedures. In addition, the INEEL field test was a prelude to the extensive field tests that were later performed at DPG prior to transferring the MMAS to the Army.

For the INEEL field test, the MMAS was driven to the INEEL site (located approximately 50 miles west of Idaho Falls, Idaho) and deployed at a mock remediation site at the Security Training Facility (see Figure 11). Assessment data was gathered by the MMAS NDE systems, downloaded to the data acquisition system in the MMAS trailer, and reviewed for accuracy by the MMAS test team. A complete inspection of the MMAS was performed following the field test to verify the continued operations of the various MMAS components, subsystems, and systems.

Figure 11. MMAS deployed during INEL field test.

The final testing stage for the MMAS involved extensive field testing of the system at DPG.

The primary objective of the MMAS DPG field tests was to verify the operations of the various MMAS subsystems and systems as they related to one another and the users (the U. S. Army's TEU). This not only required that a functional assessment of the equipment and overall system be performed, but that the operational procedures and their interaction with the MMAS be evaluated. To perform each of these "assessments," the users of the MMAS had to be familiar with the operations of the individual subsystems and the integrated system. To incorporate the necessary training (familiarization) into the test program, a test sequence was developed to allow the users to become familiar with the MMAS under "known and non-hazardous" conditions. Toward this end, the field tests at DPG were performed in three distinct phases:

1) DPG Field Test #1 - used the MMAS to inspect and identify *known and unknown munition surrogates*,
2) DPG Field Test #2 - used the MMAS to inspect and identify *known agent-filled munitions* located in "igloos" at DPG.
3) DPG Field Test #3 - used the MMAS to inspect and identify *unknown munition surrogates* in the field.

For the MMAS testing activity, "*known munitions or munition surrogates*" means the assessment team knew in advance what the munition was. This way the team could be fully aware of the potential hazards associated with the munition and could focus their attention to the munition assessment activity. On the other hand, "*unknown munitions or munition surrogates*" were selected by the TEU commander, or his representative, and the assessment team had no prior knowledge of the contents of the "unknown" item. This is referred to as a "*single blind*" selection and resulted in a very realistic assessment scenario.

DPG Field Test #1 used the MMAS to inspect and identify various munition surrogates in the field (i.e., mirroring actual discovery conditions). This was very similar to the INEEL field test performed earlier. As a precursor to Field Test #1, a complete inspection of all MMAS components, subsystems, and systems was performed by the MMAS team. These tests were performed using "known munition surrogates" placed at a mock remediation site located on the DPG post. The MMAS was deployed to the site, and TEU personnel made an assessment of the surrogates. This scenario was repeated several times to verify the functionality of the equipment and to refine the operating procedures being developed for use with the MMAS. During the latter stages of the DPG Field Test #1, "unknown munition surrogates" were placed at a mock remediation site, and TEU personnel assessed the surrogates without a prior knowledge of their contents. A complete inspection of all MMAS components, subsystems, and systems was performed by the MMAS team following each of the field tests. A one-week system retrofit was performed following DPG Field Test #1, at which time the MMAS was modified based on input provided by TEU personnel.

During DPG Field Test #2, the MMAS was used to inspect and identify known and unknown agent-filled munitions. These field tests were performed inside of a munition bunker (i.e., Igloo "G") because of the surety material used. Using munitions located in DPG bunkers replicated a real assessment scenario at a munition depot rather than the field conditions of DPG Field Test #1. *Only* TEU personnel were allowed to handle the real, agent-filled munitions. A "single blind" selection of the munition(s) was used for the latter stages of these tests. This approach resulted in a more realistic scenario including near-real situation coordination between TEU personnel performing the assessment and others supporting the assessment activity. Again, a complete inspection of all MMAS components, subsystems, and systems was performed following these tests.

For the third and final DPG field test, the MMAS was deployed to the field and assessment data gathered as before in Field Test #1 and #2. However, this time the assessment data was transferred to a central MMAS database at DPG to verify the data accuracy and quality following the data transfer. The MMAS then returned to Idaho, where a complete inspection of all MMAS components, subsystems, and systems was performed and the truck and trailer were cleaned and minor repairs/ changes made.

In addition to qualifying the MMAS equipment, the extensive field testing performed at DPG provided an opportunity to develop the operating procedures and to train the TEU personnel on the use of the system.

FIELD EXPERIENCE

The MMAS prototype is expected to see extensive field use during the summer of 1997. The field use should include responding to discovered munitions at burial sites and at test ranges at several locations throughout the United States. Responses to unknown containers are also expected. An INEEL engineer will be deployed with the system through September 1997 to support the operations and observe the performance of the system. The information gathered on system performance will be factored into the design of future systems so improvements can be made.

During MMAS field testing at DPG, a 105 mm munition, in an over-pack container, was selected for assessment by the MMAS. This munition was stored in Igloo "G" at Dugway. The first step in the assessment was X-raying the munition in the over-pack to determine the status of the firing train. Generally, this is an early assessment step because it establishes if the munition can be safely moved and provides an early indication of whether or not the munition is liquid-filled.

The first X-ray was taken through the over-pack and transferred to the MMAS trailer dark room area for processing. After processing, the X-ray film was passed to the operations commander (located in the MMAS control center) for evaluation. The commander was able to quickly evaluate the film on the light table. The film indicated that the munition was fused. However, the X-ray did not have the clarity to establish the status of the fuse. The commander used the wireless radio system located in the trailer to provide instructions to personnel in the igloo on how to adjust the X-ray generator settings to improve the clarity of the fuse components. This process was repeated until very clear X-rays of the entire fuse were obtained. The entire process required only 25 minutes to complete five X-rays.

The X-rays revealed that the 105 mm munition was fused and armed, and should not be handled. The munition (phosgene-filled) was later destroyed by TEU. The MMAS has already proved its value in the field. Improved safety and rapid accurate assessment was the result.

FUTURE DEVELOPMENT

The MMAS Phase I, System 1 is a developmental prototype. Lessons learned in the design, fabrication, testing, and field use will be factored into the design of a second system. The second system will be the production model after it is completely tested. The MMAS is designed for equipment upgrades and new state–of–the–art NDE equipment will be installed in the system as it is developed.

A larger, more capable MMAS prototype will be developed in Phase II. The Phase I systems are intended for rapid response to discovered and recovered munitions, and the Phase II systems are intended for a long-term response at sites where many munitions are recovered. The Phase II systems will incorporate a Secondary Ion Mass Spectrometer (SIMS) system, phase (solid, liquid or empty) determination system, gamma densitometer system for material identification, and an advanced X-ray system. In addition, state-of-the-art environmental monitoring equipment will be installed in the system for air, water, soil, and vegetation sampling. The first Phase II system is expected to be ready for testing in March 1999.

ACRONYMS

CWM	Chemical Warfare Materiel
DPG	Dugway Proving Ground
EOD	Explosive Ordnance Disposal
HAFB	Hill Air Force Base
INEL	Idaho National Engineering Laboratory
IRV	Initial Response Vehicle
MARB	Munition Assessment and Review Board
MMAS	Mobile Munitions Assessment System
NDE	Nondestructive Examination
NHL	North Holmes Laboratory
OSHA	Occupational Safety and Health Administration
PINS	Portable Isotopic Neutron Spectroscopy
PMNSCM	Project Manager for Non-stockpile Chemical Materiel
RAM	Random Access Memory
SCBA	Self-contained Breathing Apparatus
TEU	Technical Escort Unit