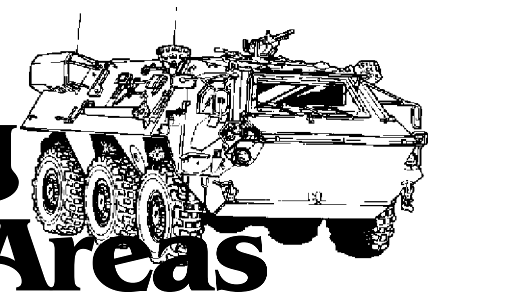
Improved Marking of Contaminated Areas



By Mr. James M. Cress

Throughout the 1980s, the Chemical Corps sought a nuclear, biological, and chemical (NBC) reconnaissance capability that would prevent the possibility of an unwarned encounter with contaminated terrain. With the type classification of the German Transportpanzer 1 Fuchs vehicle as the standard NBC reconnaissance asset, the U.S. Army first became capable of rapidly detecting terrain contaminated with chemical agents. The U.S. variant of this vehicle was designated as the M93A1 Fox Nuclear, Biological, and Chemical Reconnaissance System. The system includes a marker set which consists of a weighted base, a wire mast, and pennants for each class of NBC hazard. Enough components to assemble 175 markers are stored inside the crew compartment of the vehicle. There is a marker chute at the rear of the vehicle which allows assembled markers to be dropped outside without compromising the collective protection of the vehicle.

Starting with World War I (1914-1918), various methods of marking contaminated areas have been used. All have shared the same goal—preventing an unwarned encounter with a chemically contaminated area. The protocol for annotating the pennant or marker has remained relatively unchanged over the years. When emplaced, the unit, the date-time group, and the hazard are written on the marker, typically using a grease pencil. The identification of these markers is a common task at Skill Level 1 for all soldiers (found in Soldier Training Publication [STP] 21-1-SMCT, *Soldier's Manual of Common Tasks Skill Level 1*, task number 031-503-1019, *React to Chemical or Biological Hazard/Attack*).

The adequacy of the Fox marker system was an issue during the field-testing of the system before its type classification. With the limited number of markers on board, it was clear that placing them around a typical contaminated area would immediately consume the entire basic load of markers. Soldiers also raised issues concerning the visibility of the markers during periods of darkness and the limited amount of information available at the marker. Following the type classification, field units began to report that the markers were difficult to see and tended to tip over in rough terrain.

In 1997, the U.S. Army Chemical School's Directorate of Combat Developments at Fort McClellan, Alabama, drafted a concept for the digital marking of contaminated areas. An evaluation of a concept entitled Smart Marker was proposed. In 1998, the U.S. Army Maneuver Support Battle Lab, Fort Leonard Wood, Missouri, managed a limited-scale in-house project designed to demonstrate a long-duration infrared (IR) beacon. A circuit was then assembled based upon an LM3909 integrated circuit and other components purchased at a local electronics store.

The goal of this early experiment was to determine if a small, thumbnail-sized (1 centimeter by 1 centimeter) IR beacon could be used to improve the visibility of a Fox NBC marker for a period of two weeks without a battery change. This experiment was a success: the beacon worked for 87 days (on one AAA battery) without a failure.

The success of the beacon project prompted an investigation into the scope of the capabilities that could be included in a marking system product improvement. The Maneuver Support Center Battle Lab was sponsoring an Army advanced technology demonstration that looked at the development of decision tool software for NBC personnel. The prototype software was installed on a commercially available Windows® CE-based personal data assistant (PDA). The PDA mirrored the capabilities of laptop computers with the same graphics, text files, database utilities, and IR port. When the software contractor delivered the products, they were demonstrated on a PDA that also had a personal computer radio frequency (RF) modem card for Internet access. This allowed the user to obtain online maps via a Web site. Further investigation revealed small Global Positioning System integrated circuits that could be used inside a Smart Marker.

A demonstration to transfer a field survey form and a graphic hazard from a laptop to a PDA was conducted. This caused further interest in the concept. The Smart Marker concept was revised and improved based on the combination of technology demonstrations, market surveys, and collateral readings resulting in development of a U.S. Army Training and Doctrine Command Concept Evaluation Program (CEP) proposal.

The funding needed to conduct the Smart Marker CEP was approved in 1999. The goals of the program were to improve the visibility of the marker and increase the amount of information it makes available. A statement of work was then prepared and a solicitation for bid issued. The University of Missouri-Rolla was selected for the contract, and work began. Government personnel provided the background information on the concept and its goals for the experiment. The one government-specified constraint for the design team was to use commercial off-the-shelf (COTS) technology or components whenever possible.

The project was partitioned into four phases, and transitioning from one phase to the next was contingent upon the results of an in-progress review (IPR). Phase I was a front-end analysis that examined the varying methods of addressing the problems of the existing markers. Phase II was the fabrication of breadboards (alpha prototypes) that demonstrated function and potential and resolved any shortcomings of the existing system within the constraints specified. Phase III involved fabricating and demonstrating functioning prototypes for field demonstration. Phase IV was the demonstration of a working prototype in a limited-objective experiment.

There were three senior design teams assigned to develop three different designs. Each team consisted of one electronics/computer engineering student and two mechanical engineering students. Two of the teams also had one engineering management student each. The three teams arrived at two design approaches. Two of the groups elected to repackage a PDA to take advantage of its built-in functionality. The other team opted for the use of COTS electronic components that were coordinated by a microcontroller. Some time after the work had begun, the teams were reorganized to partition the effort. The three mechanical teams remained, but the electronics development team was consolidated.

The researchers used computer-assisted design and manufacture to create the marker prototypes. Each team had a different solution to the problem of marker stability. One team decided upon a multipod approach using multiple short legs that provided at least three points of contact regardless of its directional orientation. The multipod approach was the closest to the design of the existing marker, but the approach did not demonstrate well during the field trials. An alternative design approach used a counterweighted cylinder with a self-orienting antenna/mast. This technique had the advantage of simplicity of design but was difficult to deploy from the Fox and suffered from durability problems. The most successful mechanical design had articulated legs and was self-righting. When cost was considered, it was decided that this approach, however elegant, was not practical.

The electronics module was the most successful element of the design approach. Initially the design teams had two different approaches to the electronic functions. As the teams reviewed the requirements, it became obvious that most of the requirements could be met with a PDA. The battery well, keyboard, and visual display are the biggest parts of the PDA. These parts are unnecessary to the marker function. Two of the teams concluded that a PDA could be repackaged to meet the need. The third team thought that this approach was inefficient and that a fresh breadboard should be developed using miniature COTS electronic components. This approach was selected at a midpoint IPR.

With this decision, the teams were reorganized, and a composite team was created to design an electronics module that was compatible with all three mechanical designs. In response to the reorganization, the scope of work statement was adjusted. This team was given a size constraint for the marker and was instructed to conduct a design-to-fit study. The idea was that the actual device could be larger than the design constraint if standard design practices could configure the electronics to fit the constraint. The engineers took a modular approach, placing the components inside a clear plastic enclosure. The use of a miniature frequency-hopping transceiver ensured that it would be possible to download the marker's data from standoff distances.

A standard graphic interface was designed so that service members who are familiar with Windows products could use the supporting software easily. This approach was an unqualified success, because personnel who were familiar with Windows applications had no difficulty using the prototype software. The terminal used in the field was a standard military contract laptop computer with a Windows NT® operating system. Accordingly, soldiers with experience using these tools had no challenges with the Smart Marker and its supporting software.

The field experimentation was very successful. The Smart Marker concept evaluation demonstrated that by leveraging commercially available technology, it is possible to improve the Fox's marking of hazard areas dramatically. Simply adding different flags and a commercially available stick-on beacon makes a significant difference in the ability to detect the marker during periods of limited visibility. Leveraging available technology allows the standoff download of detailed hazard information via RF modem or digital download via the IR or the hardwire communication port. In the case of the RF mode, detailed hazard data was visible in the cab of a truck 300 meters before the marker was encountered. While this project focused upon the Fox, its findings could be useful for a number of different applications, such as minefield, hazard, and traffic-control marking.