CARTOGRAPHIC SYMBOLS FOR LANDMINE HAZARDS AND HUMANITARIAN DEMINING

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ABSTRACT

A significant void in humanitarian demining, in both landmine removal operations as well as public education activities, is the lack of a common or standardized set of cartographic symbols for maps and Geographic Information Systems (GIS). Such symbols would promote efficiency in humanitarian demining operations and provide a consistent method for symbolizing deadly hazards on maps for the public. For this reason, the Geneva International Centre for Humanitarian Demining (GICHD) recently contracted the University of Kansas to research cartographic symbols used for demining purposes, and to design a recommended set of symbols that may be implemented and promoted in the GICHD’s Information Management System for Mine Action (IMSMA). Prior to designing the recommended symbols, current symbols used by several military and humanitarian demining organizations were compiled into a catalog to assess similarities and differences in symbol designs amongst organizations. The recommended symbol set was designed based in part on existing symbols as well as standard cartographic principles and conventions. Recently, the recommended symbols have been implemented in a new version of IMSMA, and will be promulgated among humanitarian demining organizations, mapping agencies, and GIS vendors.

INTRODUCTION AND BACKGROUND

Today, over eighty countries worldwide are affected by landmine hazards or other unexploded ordinances (UXOs) as the result of conflicts or potential conflicts over the past several decades. The major objective of humanitarian demining activities is to remove these hazards and to return the cleared land to civilian populations and local governments. Maps and Geographic Information Systems (GIS) serve a necessary role in humanitarian demining for the management and graphic display of geospatial information that is critical for safe and efficient clearance operations. The Information Management System for Mine Action (IMSMA), developed and distributed by the Geneva International Centre for Humanitarian Demining (GICHD), is the leading information system and GIS for the collection, storage, and mapping of information for minefields and mine actions (landmine removal processes). Currently, IMSMA is deployed in more than fifty countries, encompassing more than 80% of the humanitarian demining programs around the world (1). IMSMA is endorsed by the United Nations as the preferred information system for humanitarian demining (2).

Humanitarian demining operations require numerous cartographic symbols to represent the various attributes of landmine hazards and mine actions in graphic form on maps in GIS-based systems such as IMSMA. For example, it is often necessary to map the specific type of ordnance(s) found in a minefield, or the specific phases of the demining process that have been completed or are in progress during minefield clearance activities. In addition to producing maps to support humanitarian demining operations, IMSMA is also used to produce general maps of landmine hazards for local civilian populations in mined regions. The current version of IMSMA includes over 150 point, line, and area symbols for representing various categories of hazards, demining processes, accidents, and location features (e.g., airfields, hospitals, towns). Since poorly designed cartographic symbols may cause map misinterpretation with potentially fatal consequences, it is of paramount importance that humanitarian demining symbols not be ambiguous, confusing, or non-intuitive to civilians and demining personnel. In this regard, current IMSMA symbols are inadequate. One problem is that many current IMSMA symbols are composed of letters for English abbreviations, perhaps making them confusing and difficult to understand for non-English speaking demining personnel and civilians. For example, the current IMSMA point symbol for a minefield is a red diamond with the initials “MF” in the center of the diamond. Additional drawbacks of current IMSMA symbols include duplication of symbols to represent a variety of different
features or processes, and several symbols in similar categories do not relate to each other in a tiered or hierarchical structure. Due to these and other shortcomings, there is ample room for an improved set of cartographic symbols.

**STANDARDIZED SYMBOLS FOR HUMANITARIAN DEMINING**

Symbols on maps serve as a graphic language, whose primary purpose is to communicate or to transfer information between a cartographer and map users (3). The ultimate success of the communication is based on the ability of map users to decode symbols correctly into their real-world meaning. Multiple map symbols representing the same real-world feature, event, or process may create confusion and inefficiency for map users. A benefit of standardized map symbols is that a common graphic language is used during this communication process, which may reduce or eliminate the potential confusion and inefficiency resulting from multiple symbols that represent the same feature, event, or process.

The need for a redesigned set of IMSMA symbols highlights an important issue in humanitarian demining—the lack of a common or standardized set of cartographic symbols for landmine hazards and mine actions. The International Mine Action Standards (IMAS) (4), which provide detailed specifications for many standards and procedures in humanitarian demining, do not advocate any specific standards for map symbols. However, a standardized set of map symbols would provide a multitude of benefits for humanitarian demining efforts. First and foremost, standardized map symbols would provide a consistent method for marking dangerous landmine hazards on maps. Second, standard symbols would promote efficiency in demining operations by reducing the time required by civilians and demining personnel to learn additional symbols used by other organizations. Third, standard symbols would promote the exchange of maps and information as organizations would not be required to replace map symbols from other organizations with their own symbols. Rather, a common symbology scheme would provide a seamless transition for information exchange between organizations.

**EXISTING HUMANITARIAN DEMINING SYMBOLS**

Existing map symbols for landmines, minefields, and mine actions were considered prior to designing the recommended symbols for IMSMA. The first phase of the project was to collect existing map symbols and to organize them into a symbol catalog, which would provide an easy way to identify any common trends which could be incorporated into the design of the recommended symbols. Symbols were gathered from several sources in order to collect a representative sample that spanned the broad spectrum of humanitarian demining organizations from a variety of countries and cultures. Sources included military and governmental organizations (e.g., NATO), international organizations (IOs) (e.g., United Nations Mine Action Service (UNMAS)), non-governmental organizations (NGOs) (e.g., Mines Advisory Group (MAG)), mine action centers (MACs) (e.g., Croatian Mine Action Centre (CROMAC)), GIS software vendors (e.g., ESRI), and map libraries (e.g., Geography and Map Division of the Library of Congress). Symbols were either collected from maps or documents available on websites, or were provided by personnel at each of the organizations. In total, symbols were gathered from over forty organizations.

The symbol catalog reveals many similarities in symbols among military organizations included in the survey. Many military organizations adhere to formally standardized symbols in military documents, and in many cases there are similarities across organizations. For example, symbols in NATO’s APP-6A: Military Symbols for Land Based Systems (5) are nearly identical to those in the U.S. Department of Defense’s MIL-STD-2525B: Common Warfighting Symbology (6). NATO symbols from APP-6A have also been adopted by non-NATO member countries such as Australia, indicating a broader appeal of these symbols. Initially, NATO symbols were considered for integration into IMSMA due to the standardization and widespread acceptance of these symbols. However, it is difficult to extend military symbols for humanitarian demining purposes for at least two main reasons. First, although NATO symbols in APP-6A include symbols for many categories of landmine hazards, they lack symbols for many of the landmine removal processes that are necessary for humanitarian demining. Second, many military symbols are abstract and were designed for personnel with specific training, thus they do not lend themselves well as public information symbols for civilians. For example, the current standard NATO symbol for an anti-tank (AT) landmine is a black circle, which may be easily misinterpreted as a point symbol for a town or city by those inexperienced with NATO symbology.

In contrast to the military symbols, there is much more variation in the symbols from the humanitarian demining organizations such as the IOs, MACs, and NGOs. For example, the Albanian Mine Action Executive, the Bosnia-Herzegovina Mine Action Centre, and the Croatian Mine Action Centre each use a different symbol to represent a cleared minefield, despite the geographic proximity of these three MACs to one another. Although there are considerable differences in symbols, some general conventions common across organizations do exist, particularly in
the selection of colors. For example, red is the consensus color for symbolizing landmine and minefield hazards, and green or blue are commonly used colors for cleared minefields or safe areas.

**DESIGNING HUMANITARIAN DEMINING SYMBOLS**

In addition to existing symbols, a number of additional factors were considered during the design of the recommended symbols for IMSMA. Major guidelines included the following:

1) **Landmine hazard and minefield symbols were designed to imply danger.**

   The most important consideration for humanitarian demining symbols is that all landmine hazard and minefield symbols should be designed in a manner that clearly implies danger to civilians and demining operations personnel. By replicating hazard signs used to mark minefield perimeters, hazard symbols may be more recognizable on maps. The international standard for minefield marker signs is a red triangle and a white skull and crossbones, which is specified in the IMAS (7). Because of the prevalence of the red triangle for marking minefields, Mine Risk Education (MRE) personnel instruct civilian populations in mine affected regions to recognize the red triangle as a symbol of danger. Due to the inherent meaning of the red triangle in mine affected regions, red triangles were incorporated into all point and area symbols for landmine hazards and landmine removal processes that may pose danger to civilians or demining operations personnel.

2) **When possible, intuitive, pictorial symbols were designed.**

   An important function of IMSMA symbols is to serve as public information symbols on landmine hazard maps for civilians. An advantage of pictorial symbols is they are easily understood and are advantageous for the non-specialist and the general public (8). A number of cartographic studies have reported the benefits of pictorial symbols on maps for the public (9, 10, 11). For this reason, intuitive, pictorial symbols that cross cultural boundaries as much as possible were developed, such as an icon of a skull and crossbones inside a red triangle to represent a minefield and an icon of a mechanical flailing machine to represent the mechanical demining process. A drawback of pictorial symbols is that they may be more difficult than abstract symbols to draw by hand in the field, however this benefit has been minimized in recent years with the integration of handheld computers and GIS software in humanitarian demining fieldwork.

3) **Symbols were designed in a hierarchical or tiered structure.**

   The recommended symbols for IMSMA were organized into a hierarchical or tiered structure, creating a taxonomy of symbols that allows for easy display of general or specific attributes for landmine hazards and mine actions. For example, a red triangle and a white skull and crossbones compose the base point symbol for a general landmine hazard. When it is necessary to depict the specific category of landmine hazard (e.g., dangerous area, mined area, or minefield), an additional graphic attribute, a border or frame, is added to the base symbol. A hierarchical or tiered structure is beneficial because it creates a versatile symbol set of general symbols appropriate for maps for civilians and more specific symbols necessary for demining operations.

4) **Appropriate colors were selected for symbols.**

   The selection of appropriate colors to represent dangerous and safe areas was an important challenge in designing the recommended symbols. Although perceptual studies have found that red implies danger effectively in many western cultures (12, 13, 14), red has different meanings in other cultures. However, red was chosen to represent all landmine hazard symbols based on standard conventions in humanitarian demining. For example, the IMAS specify red as the standard color for marking minefield signs, and red is the color used by an overwhelming majority of humanitarian demining organizations for landmine hazard and minefield map symbols. In addition, red is an acceptable color for symbolizing prohibited areas on safety signs according to standards issued by the International Organization for Standardization (ISO) (15). Green was chosen as the color for cleared minefields, again following general conventions in existing humanitarian demining symbols as well as the ISO color guideline for symbolizing safe conditions. It is important to note that the color of symbols in IMSMA may be changed if the default colors are not suitable for cultural reasons. Another important consideration in any symbol design is the selection of colors that are friendly to those with color vision impairments (16). For this reason, colors for symbols are based on color-blind friendly schemes recommended by Brewer et al. (17).

5) **Symbols were designed to print or photocopy in black and white.**
Color is used for added emphasis in distinguishing between the recommended symbols, and graphic attributes other than color are utilized to ensure that all symbols may be differentiated when printed or photocopied in black and white. The ability to print or photocopy symbols in black and white is crucial since some humanitarian demining organizations do not have color printing capabilities, particularly in field offices.

An important phase in the design of the recommended symbols was a qualitative evaluation of preliminary symbol designs by twenty-one demining operations personnel at the 2004 IMSMA Summer Workshop in Geneva, Switzerland. Participants represented seventeen total countries. Following a focus group discussion regarding the recommended symbols, participants completed an evaluation form on which they were encouraged to comment on the strengths and weaknesses of the preliminary symbol designs. Following the evaluation, notes from the focus group and results from the evaluation forms were assembled to identify specific symbols that needed improvement. Feedback from demining operations personnel was very beneficial in the development of the recommended symbols for IMSMA as individual strengths and weaknesses for symbols were discovered, prompting the modification of some symbols.

**PROMULGATION OF SYMBOLS**

The recommended symbols have been incorporated into a new version of IMSMA that is currently under development, and will be integrated into the humanitarian demining community with the release of the new IMSMA. Future work includes additional promulgation of the symbols to humanitarian demining organizations, mapping agencies, and GIS vendors through workshops. One of the goals of the promulgation efforts is to draw attention to this important void in landmine removal activities, with the hope that a standardized symbol set eventually will be adopted by the humanitarian demining community. Of the many benefits for standardized symbols in humanitarian demining, the greatest potential is to improve safety for demining operations personnel and civilians living in mine affected regions.

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BIOGRAPHY

John Kostelnick is a Ph.D. candidate (ABD) in the Department of Geography at the University of Kansas (U.S.A.) where he serves as a graduate research assistant. Over the past year and a half, he has researched cartographic symbols for landmine hazards and mine actions, and has proposed a new set of cartographic symbols for humanitarian demining. At the University of Kansas, he has also served as a graduate research assistant at the Kansas Applied Remote Sensing (KARS) Program, a graduate research assistant for the Polar Radar for Ice Sheets Measurement (PRISM) project, and a graduate teaching assistant for cartography and map reading courses in the Department of Geography. Currently, he is also a GIS instructor at Haskell Indian Nations University. His other research interests include geographic visualization, GIS applications in human geography, and the cultural geography of the United States. He holds a Master of Arts (M.A.) degree in Geography from the University of Nebraska—Lincoln (Specialization in Cartography, GIS, and Remote Sensing) and a Bachelor of Arts (B.A.) degree in History from Iowa State University.