Challenges for Map Symbol Standardization in Crisis Management

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ABSTRACT

A wide range of local, regional, and federal authorities will generate maps to help respond to and recover from a disaster. It is essential that map users in an emergency situation can readily understand what they are seeing on these maps. Standardizing map symbology is one mechanism for ensuring that geospatial information is interpretable during an emergency situation, but creating an effective map symbol standard is a complex and evolving task. Here we present preliminary results from research into the application of the ANSI 415-2006 INCITS Homeland Security Map Symbol Standard, a point symbol standard intended to support emergency management mapping for the U.S. Department of Homeland Security. This standard has so far not been widely adopted across the full range of DHS missions, and we elaborate on key issues and challenges that should be accounted for when developing future map symbol standards for crisis management.

Keywords

Symbology, Mapping, Standardization, Crisis Management, Interoperability

INTRODUCTION

Developing and maintaining situational awareness during a disaster often depends on the efficient creation and dissemination of maps and other geospatial products that describe disaster impacts and available resources for response and recovery. Such products must be easily ingested by decision makers and other authorities, and map symbol standardization is one way to help ensure that communication between mapmakers and map users is effective and efficient (Dymon, 2003, Kostelnick et al., 2008). In basic terms, map symbol standards formalize relationships between spatial features and their representation on maps.

Our work focuses on the map symbol needs of the United States Department of Homeland Security, a federal domestic security entity composed of a large number of agencies and mission areas, each with its own mapping needs and capabilities. Our research focuses on the broader challenge of developing processes for map symbol standardization. In the near term we have begun by focusing attention on the current ANSI 415-2006 INCITS Homeland Security Map Symbol Standard (ANSI, 2006). Our examination of the ANSI standard is intended to elaborate key issues associated with the adoption / rejection of map symbol standards.

This paper begins with a discussion on existing map symbol standards, focusing specifically on the ANSI standard that is the initial subject of our research. We continue with methodological details of our study, preliminary results from interviews with mapmakers and map users at DHS, and a set of key challenges for symbol standardization that emerge from our results. We conclude with reflections on our results and future directions for map symbol standardization research.

Reviewing Statement: This paper represents work in progress, an issue for discussion, a case study, best practice or other matters of interest and has been reviewed for clarity, relevance and significance.

BACKGROUND

A variety of map symbol standards related to crisis management are currently in use today. Examples include standards for demining (Geneva International Centre for Humanitarian Demining, 2005), military operations (U.S. Department of Defense, 2008), and emergency response (American National Standards Institute, 2006, Spatial Vision Ltd., 2007). The focus of most contemporary symbol standards is on point symbols, although some recent efforts (such as those outlined in Kostelnick, 2008) have also suggested standards for symbolizing area features.

Our work centers on the study of the ANSI 415-2006 INCITS Homeland Security Map Symbol Standard, a point symbol standard intended to improve information sharing during crises. The ANSI symbol set is designed for multiple phases of emergency response: (1) planning/preparedness, (2) immediate response (as an event occurs), (3) intermediate response (after an event ends), and (4) long-term recovery. Development of the ANSI standard featured five steps: (1) define what is meant by a symbol, (2) survey existing emergency symbology, (3) classify existing symbols by their features and content, (4) produce a symbol matrix showing the recommended symbol for each object and other variants found during the symbol survey, and (5) logically define each symbol in the matrix (Dymon and Mbobi, 2005). The recommended symbols were evaluated in an online survey by participants in emergency response fields. Symbols that did not receive a 75% approval rating were either deleted or modified (22 of 214, roughly 10% of the total set). However, a complementary study of the ANSI symbols with 50 firefighters in California produced very different results, with only 7 of the 28 fire-related symbols yielding a comprehension rating above 75% (Akella, 2009).

The symbols in the ANSI standard are designed for large scale mapping and monochromatic reproduction. The ANSI set includes four categories of symbols; incidents, natural events, operations, and infrastructure. The standard also includes a set of four outer frames that are designed to identify these categories, and frames have four possible line types designed to signify operational status (Figure 1).

Members of the ANSI standard development team indicate that there has not been widespread adoption of the ANSI standard at DHS, despite its clear relevance to DHS missions and the inclusion of DHS users in the design process (McCarty, 2009). Our focus on map symbol standardization begins with a close look at the adoption and use (or lack thereof) of the ANSI standard by mapmakers and map users at DHS.

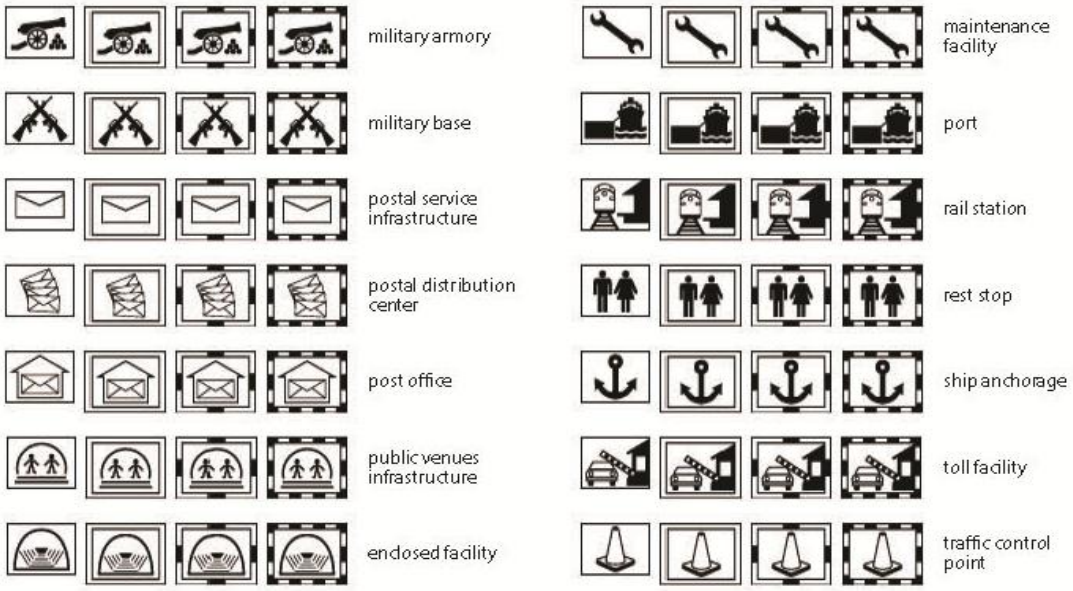

Figure 1: Examples of map symbols included in the ANSI standard (complete set viewable at www.fgdc.gov/hswg/)

METHODOLOGICAL APPROACH

In our study we interviewed 14 mapmakers and map users at a range of DHS mission areas, including: Customs and Border Patrol (CBP), Infrastructure Information Collection Division (IICD), United States Coast Guard (USCG), United States Fire Service (USFS), National Operations Center (NOC), Federal Emergency Management Agency (FEMA), and the Domestic Nuclear Detection Office (DNDO). Participants for this study were identified for us by DHS project sponsors as key consumers of current and future map symbol standards.

Common interviewing methodologies differ according to the amount of structure they entail. Structured interviews do not provide for flexibility, but allow easier comparisons across multiple subjects. Semi-structured interviews allow the researcher to adapt questions and develop new probes during each interview depending on the context of the discussion (Silverman, 2004). A semi-structured interview format was chosen for this research to ensure that we would be able to explore emerging issues and critical incidents with participants.

To develop a set of interview questions the project team compiled and edited questions iteratively in conjunction with feedback from project sponsors. Additionally, one map expert from DHS reviewed the question set before it was finalized. A total of 21 interview questions were developed to cover the following topics: adoption and use of the ANSI Standard, the use of other map symbol standards, critical incidents with respect to the use of map symbology, technical/organizational challenges with respect to standard development, and ideas for candidate processes to develop new symbol standards. Additionally, we designed several interview questions to make use of participant-provided map examples. Prior to each interview, we asked participants to provide map examples from their daily work so that we could discuss symbology-related challenges associated with those artifacts. The complete set of interview questions developed for this study is provided as an online supplement (www.personal.psu.edu/acr181/ISCRAM_Interview.pdf).

Data Analysis

We were given permission to record audio for 10 of the 14 interview sessions. Recorded sessions were transcribed, unitized into individual statements, and coded according to one of four themes that emerged during the interviews: (1) adoption of the ANSI standard, (2) barriers to using the ANSI standard, (3) technical and organizational issues for symbol standardization, and (4) in house standards and associated map examples. The following sections summarize participant responses. To protect confidentiality, personally indentifying information has been removed. Written notes from the 4 interviews that were not audio recorded were used to help contextualize other responses, but all direct quotes in this paper are from audio-recorded sessions.

INTERVIEW RESULTS

The following sections summarize our initial findings from participant interviews. The results are organized by the major themes that we used to structure the question set.

ANSI INCITS 415-2006 Adoption

A key focus of this work was to assess the use of the ANSI Standard to characterize its adoption and suitability to a wide range of contemporary DHS missions. Although they were identified by DHS as consumers of the ANSI standard, we found that several of our participants were not familiar with the standard. Several other participants recognized some of the symbols, but were not aware of the complete standard.

A majority of participants were familiar with the standard, with a small subset having been involved in its development. However, none of the participants we interviewed in this study use the entire ANSI standard on a regular basis. It was more common for participants to make use of a small number (5 – 15) of the symbols as part of an in house map symbol standard customized to the specific mission of each group.

It is important to note that there was one reported effort to adopt the ANSI standard in its entirety for an exercise. However, the participants in the exercise "couldn't figure out what the maps meant." Our participant reported that "even though we got commitment from the technical folks and the analysts [to use the symbol standard] there was still a gap – they just really weren't able to do anything with it." The exercise was concluded early because of the difficulty in using the symbol set.

ANSI INCITS 415 Barriers to Use

Comments on barriers of use fell generally into one of categories: (1) poor fit to the unique missions of each group, (2) overly complex graphical icons that are ambiguous, and (3) symbol design characteristics that reflect incompatible mission and format constraints.

First, there is a significant mismatch between the ANSI symbol set and the feature types that mission areas across DHS need to display, referred to by one participant as the "operational perspective." One participant stated that the standard was "more terrestrial-based" which didn't work well "since we're a maritime organization." Similarly, another participant stated that their "…mission deals with installations and facilities,

not incidents and events...there are very few symbols which would apply." Overall, no participants reported that the hierarchical structure and symbols of the ANSI standard adequately matched their operational perspective.

Second, participants indicate that based on their experiences, many of the symbols are too intricate and difficult to interpret for their map users. One participant stated that the symbols are "just plain too dense, you cannot discern what is inside the frame" and another said that the "symbol set traditionally broke down based on the resolution of the product." Participants generally thought that the standard was most appropriate for large scale mapping. Our participants primarily make maps at smaller scales to cover entire urban areas, states, and regions for planning, preparedness, and mitigation (and rarely for response).

Despite the graphic complexity of the pictorial icons, participants found them to be ambiguous. One participant stated that "some [symbols] are not really interpretable, just by looking at them, without reading the definition to see what it means" which is problematic because the "[symbol] definitions leave a little bit to be desired."

A final barrier to use is that the ANSI standard was designed so that it could be reproduced in black and white. However, participants stated that there is rarely a situation when a color printer or screen is unavailable. When color is used in the ANSI standard, it is used redundantly with frame patterns to represent the operational status of features. While acknowledging the utility of representing operational status, none of our participants have or make use of data that includes operational status information. It is important to note that one component of the ANSI standard that was well received was the use of frame shape to represent symbol categorization.

Technical and Organizational Issues with Symbol Standardization

Generally, participants did not think that symbol standard adoption involved serious technical issues. There were minor technical concerns regarding the ANSI standard specifically relating to the availability of the standard as a TrueType font only.

Many of our participants are in mission areas that are actively developing or already making use of web mapping services to create and disseminate maps. When asked about the difficulty of implementing new standards in these applications, participants indicate that as long as data sources provide appropriate metadata, they do not see significant challenges associated with applying symbol standards in these systems.

In contrast, our research indicates that organizational challenges require much more attention than technical challenges. The consensus from our participants is that DHS would need to issue and enforce a policy that requires mission areas to develop, share, and apply map symbol standards. Additionally, it is essential that any standardization is implemented in such a way that it includes input from mapmakers as well as map users and provides mapmakers with the flexibility to modify the standard when necessary. Flexibility also assumes continued refinement of the standard as the missions evolve, as one participant stated that, "…there has to be some maintenance on that symbology set...It can't just go out there and then 3 or 4 years later, everybody is complaining and now we're going to do something about it."

In House Symbol Standards

Since our participants indicated that they are not using the ANSI standard, we asked them to tell us if they were using other map symbol standards instead. We learned that informal, in-house standards were in use at most DHS mission areas. The formality and complexity of these in house standards ranges between each mission area. These standards are collections of symbols stored in ESRI style files that have been compiled from ESRI symbol palettes and other sources. We asked participants to describe how these symbol standards were developed, and most described an ad hoc, one time procedure to compile and choose symbols for their in house standard. These standards do evolve over time as user feedback and mission requirements call for changes, but no participants reported an iterative or structured standard development process to proactively review and refine their standards.

We asked participants their opinion on developing one comprehensive symbol standard for use for all DHS mapmaking. Participants were consistently negative on the prospects of developing such a standard. In contrast, participants suggested that formalizing, refining, and sharing existing in-house symbol standards is a fruitful direction for future map symbol standardization efforts.

CHALLENGES FOR SYMBOL STANDARDIZATION

Our case study on the adoption and use of the ANSI symbol standard at DHS illuminates several key challenges for standardizing map symbols. These challenges can be used in turn to help formulate new symbol standard processes and to inspire further research on map symbology issues in crisis management:

- *Symbols must support wide range of mission needs beyond basic emergency response*
- *Symbols must support wide range of output formats and map scales*
- *Symbols must be as simple as possible to avoid interpretation issues*
- *The process of standardization must involve mapmakers as well as map users*
- *Symbol categorization can be as important as the symbols themselves*
- *The ability to see a map from one's preferred perspective is important during an emergency*
- *In house symbol standards can be used to inform development of new formal standards*
- *Organizational structures must be implemented to foster the development and use of symbol standards*

Supporting mapmakers and map users with effective map symbol standards will require new technical and organizational solutions to these challenges. Future crises will no doubt add issues to this list as nascent symbol standards are tested in real world situations.

CONCLUSIONS AND FUTURE WORK

DHS users' failure to adopt the ANSI standard hinges on a mismatch between their mission needs and the specific emergency response tasks taken into account during ANSI standard development. The ANSI standard was not designed to support detailed planning and analytical work that our participants conduct. Our participants are also not limited to output format constraints that were a key part of ANSI standard development. These facts reveal that the problem is not the ANSI standard itself, but rather that there is an ongoing need for additional standards that satisfy a wider variety of mission types beyond the most basic response-oriented goals.

Standardization is an evolving goal, as output formats and mission needs constantly change. New symbol standard processes must take these and the other challenges we have outlined into account. In our next phase of research we will focus on developing a new symbol standardization process and evaluating this process with mapmakers and map users who work on crisis management issues at DHS.

ACKNOWLEDGMENTS

This work is supported by a contract from the U.S. Department of Homeland Security Science and Technology Directorate, Command, Control and Interoperability Division. The views expressed here are of the authors, and do not reflect the official positions of the Department of Homeland Security or the Federal Government.

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