

# **Spatial Decision Support for Urban Search and Rescue and Disaster Management**

C. Donald Heth, Grzegorz Dostatni, Edward H. Cornell

University of Alberta, Department of Psychology, Edmonton, AB T6G 2E1, CANADA

Tel. (780-492-4721) Fax (780-492-1768)

Email: dheth@ualberta.ca, grzegorz@perfectphotos.ca, ecornell@ualberta.ca

## **Abstract**

The search and rescue community in Canada is comprised of highly dedicated individuals who are often natural geographers comfortable with topographic maps. However, availability of current state-of-the art geographical technology is frequently problematic and subject to budgetary constraints. In this paper we present a set of solutions, developed as a software package, that provide spatial data displays and relational database functionality to the search and rescue community.

## **1. Objective**

Each year scores of North American adults and children become lost, disoriented or otherwise unable to return home (Cornell & Hill, 2006). The search for missing or lost persons usually involves both civilian and police agencies working under severe time constraints to respond to the emergency. At the same time, due to the life-and-death implications of the decisions involved, accuracy and accountability are paramount. In this paper we present our implementation of a mobile geographical information system called First Response. Our objectives were to provide a bilingual decision support tool to the

search and rescue (SAR) community in North America. We strive to provide the advantages of a real-time geo-spatial information system, while at the same time including an automated log of major decisions for accountability and future review. In addition, the application gathers local statistical information about missing persons that is used to improve its predictive capability.

## **2. GIS data visualization**

Many SAR personnel are heavily involved in outdoor activities and are intuitive geographers comfortable with topographic maps. Despite their familiarity with maps in general, major GIS applications (ArcInfo, GRASS) remain unattainable for most civilian and volunteer groups due either to the cost of acquisition or the cost and time required for personnel training. Furthermore, conventional GIS platforms are often unsuited to the demands of emergency response missions in other respects: (1) The user interfaces are designed for spatial data analysis and are less pertinent to the variables that characterize a SAR response; and (2) the data models typically do not incorporate journaling information that SAR missions require to ensure proper accountability.

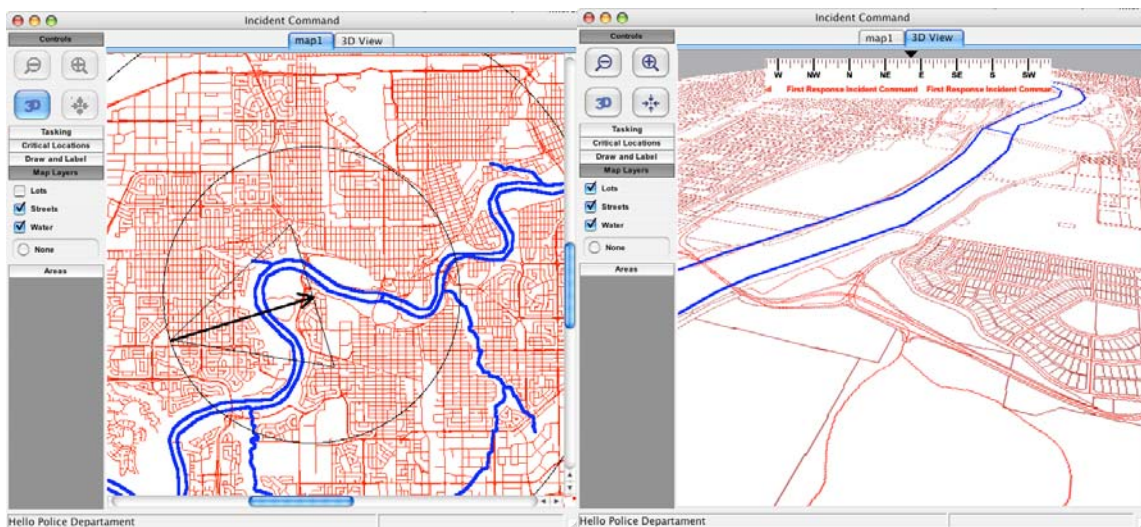
Nevertheless, it remains true that geographical information science has much to offer to SAR organizations. The search for a missing individual in natural or built environments, or a response to a disaster, is a process that unfolds in both space and time. The director of a SAR operation must assess the odds of target in a search region, prioritize responses, and calculate posterior odds that the target will be located in a region

that has been searched. Spatial analytic operations such as buffering and binary overlays are clearly relevant, and can provide useful information to guide the decision about where to search. Furthermore, access to multiple spatial databases, such as cadastral or other parcel-based information, can be of great assistance in organizing a response. The primary challenge to geographical information science in this area, then, is to provide the richness of spatial data analysis with a user interface that meets the demands of a lay client base.

First Response Incident Command attempts to provide access to base GIS information (hydrology, forestry, city blocks, elevation rasters, and aerial photography) through an intuitive interface. The user is presented with a schematic map of the area with the ability to select individual layers as well as change individual layer color and width. In an urban environment, the program allows input by using geographic coordinates (lat/long, 3TM, UTM, etc) as well as city addresses. Full correspondence between different coordinate systems is maintained whenever possible: The user can obtain the closest address from given geographic coordinates, or obtain a list of addresses contained in a geometric shape. The latter is an especially valuable informational display for managers of SAR or disaster response incidents who must estimate personnel requirements for tasks such as grid-based searches or door-to-door canvassing.

In addition, First Response is capable of generating flybys of the current situational map in full 3D. A customized algorithm provides interactive views, textured with the raster and vector overlays chosen by the user. Because of the inherent difficulty

in maintaining situational awareness of one's position and orientation in a virtual environment, and the need for SAR personnel to have that awareness at all times, the focal position of the 3D environment is obtained through the familiar 2D map. The user first selects the main point of focus and then indicates the desired radius at which the camera will orbit that point. A 3D environment is generated and presented to the user in a separate tab. The program provides immediate feedback describing the world horizon and the initial orientation of the camera (Figure 1). Current orientation of the camera is indicated by the virtual compass at the top of the screen.



**Figure 1.** Steps necessary in generating a three dimensional environment map. Left panel: The user chooses a region of interest and a position (arrow head and tail, respectively). Right panel: Motions in the 3-D window are restricted into the circumference of the circle drawn on the 2-D map, or along an arc from the circumference to the zenith above the region of interest.

### **3. Real-time data visualization**

Besides displaying standard GIS data, the program must allow the maps to be annotated with relevant, task specific, information. Examples include designated areas to be searched and an icon representing task assignment within that area. Other information, such as the expected rate of walking, distance traveled and deviation from a known heading can also be represented on a map. (Cornell & Heth, 1996). Due to the number of tasks generated during a long search, it is imperative to allow individual control over all information that appears on the map. We chose to design the interface so that multiple methods are available for recording the same task. For example, icons can be interrogated either through a menu mechanism or by clicking on their region of the map. Either action displays informational forms which can then be reviewed, amended, or updated. Similarly, as new teams are dispatched to different areas, their locations can also be registered by menu actions or by dragging and dropping icons on the map. Areas, icons and layers can be hidden at any time to encourage the investigation of possible patterns of behavior. First Response maintains a narrative of the mission through an extensive use of logs. A report detailing events, information and task assignments can be generated at any time. In addition, a detailed chronology is maintained of every task, allowing search managers to be aware of both the current and past states of task assignments. It also provides a historical record of when and how information was developed. Many search operations, especially involving children in urban areas, can acquire policing implications; the information known at a given time, and the chain of

custody of possible evidence, thereby becomes a matter subject to judicial review. First Response provides resources that can assist law enforcement agencies in establishing and maintaining that information.

#### **4. Data input**

Although most organizations charged with SAR operations in Canada do not maintain their own geomatics, they are often allied with civic organization that have extensive and high-quality spatial data. First response was originally designed for urban SAR applications, and because of this heritage, is based on civic maps. The primary display emphasizes survey fabrics, but other vector information is also anticipated. Three-dimensional vectors can be used in the construction of the 3-D visualization described above. Because of its origins in surveys of Canadian cities, the native coordinate system assumes that data is input in the 3-degree transverse Mercator system used across Canada. Raster information is also displayed using GeoTiff images.

#### **5. Future work**

The software design allows for number of possible extensions. Because search decisions are strongly predicated on projections of target behaviors and on the analysis of possible scenarios, it would be useful to model lost person behavior using geosimulation techniques (Benenson & Torrens, 2004). The technology that exists right now could allow to obtain and keep track of weather information, validate area coverage from GPS tracks,

use hand held computers to store detailed canvassing information and perhaps even real-time tracking of search teams in the field.

## **6. References**

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## **7. Acknowledgments**

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