Mapping in the Wild: Toward Designing to Train Search & Rescue Planning

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Figure 1: A map annotated with standard GPS waypoint markers during SAR operations, which enables collaborative planing of operations and real-time sharing and tracking of plans.

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Abstract

Search and rescue (SAR), performed to locate and save victims in disaster and other scenarios, primarily involves collaborative sensemaking and planning. To become a SAR responder, students learn to search within and navigate the environment, make sense of situations, and collaboratively plan operations. In this study, we synthesize data from four sources: (1) semi-structured interviews with experienced SAR professionals; (2) online surveys of SAR professionals; (3) analysis of documentation and artifacts from SAR operations on the 2017 hurricanes Harvey and Maria; and (4) first-person experience undertaking SAR training. Drawing on activity theory, we develop an understanding of current SAR sensemaking and planning activities, which help explore unforeseen factors that are relevant to the design of training systems. We derive initial design implications for systems that teach SAR responders to deal with mapping in the outdoors, collecting data, sharing information, and collaboratively planning activities.

Author Keywords

Training, disaster response, search and rescue, maps, sensemaking, planning, fieldwork, activity theory.

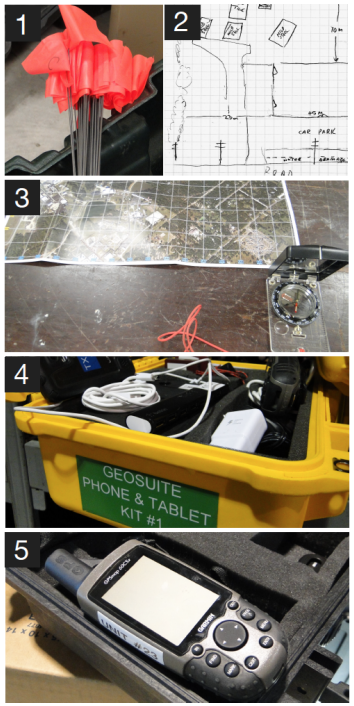

Figure 2: Different methods used by SAR responders for outdoor navigation, information seeking, and planning. **(1)** Hansel and Gretel is a survival strategy in which a responder leaves a trail of flags to retrace their path. **(2)** Sketch maps are used to establish plans. **(3)** Compass and paper maps used for navigation and orientation. **(4, 5)** Digital maps on smart devices are used for real-time location updates.

Introduction

Search and rescue (SAR) is a multi-hazard discipline, needed for a variety of disasters (e.g., earthquakes, hurricanes) [15]. In this complex cooperative work, planning and spatio-temporal skills are crucial to success [12, 13], thus, responders constantly train to retain and enhance their knowledge and competence. However, traditional training methods (e.g., real-life simulated drills, classroom courses) present challenges in advancing disaster response training [1]. Training in classroom environments lack realism, while real-life drills may be unavailable, costly, and risky, thus, new approaches to training are valuable [1].

Prior studies contribute rich insight into disaster response practice, providing new ways to improve training and field operations through system design [5,6,9,12,14]. Such studies investigate different components of disaster response: collaboration and coordination practices [13, 14], sensemaking in emergencies [11], situational uncertainty of disaster response [6], and on-line social convergence in disaster [7]. SAR sensemaking and planning are underexplored.

This research synthesize qualitative data to understand SAR collaborative sensemaking and planning practices. From this understanding, we develop design implications for future training simulations (e.g., location-aware and mixed reality games [1, 10, 13]) to support SAR preparedness.

Methods and Analysis

Based on our study of prior work and motivation, we propose the following research questions: ***what are the salient components of SAR practice?*** and ***what are the design implications that support these components?*** To answer these research questions, we employed qualitative methods to understand SAR sensemaking, planning, and mapping practices. We synthesize four data sources: **(1)**

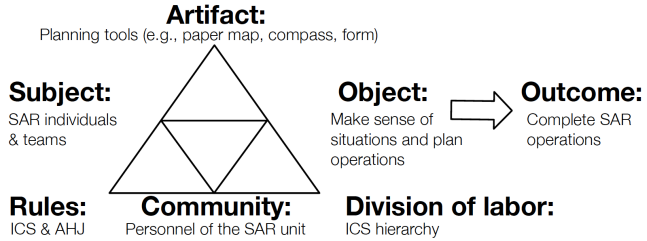

Figure 3: The Activity Theory framework guided our analysis [8].

semi-structured interviews with experienced SAR professionals; **(2)** online surveys of SAR professionals; **(3)** analysis of documentation and artifacts from SAR operations on the 2017 hurricanes Harvey and Maria; and **(4)** first-person experience undertaking SAR training. Table 1 summarizes participants for the interviews and surveys. Participants in this study were recruited during a visit to the Texas A&M Engineering Extension Service training base and the Texas Task Force 1[1] headquarters.

Interview scripts, surveys, and documentation were coded and emerging themes were analyzed. To integrate themes across these data types, we draw on activity theory (AT), a conceptual framework organized around the fundamental concept of *activity* [8], which helps to frame the socio-cultural aspects of SAR. We focus on several activities of SAR: how information is collected individually and collectively; the different uses of artifacts (e.g., paper/digital maps (Figure 2)); and how plans are constructed, shared, and tracked. We connect themes observed in the data to the core elements of AT [8] in Figure 3. From these themes and connections, we derive design implications that inform the design of training systems that simulate essential components of SAR practice and training.

[1] https://texastaskforce1.org

	Exp.	Position
P1	32	Instructor
P2	10	Training manager
P3	12	Technician
P4	30	Task Force leader
P5	35	Planning chief
P6	28	Search leader
P7	8	Volunteer

Table 1: List of all experienced SAR participants with various positions that took part of this study, including the face-to-face interviews (first 3 participants) and online survey. Length of experience (Exp.) is in years.

Figure 4: Different methods of the marking system used to keep track of the SAR operation plan:
(1) Spray painting buildings.
(2) Standardized GPS waypoints used in digital maps (see Figure 1).

In the remainder of the paper, we synthesize the data we collected, providing quotes from interviews and survey data, using Table 1 to attribute source. We then build design implications for future training systems.

Preliminary Results: SAR Planning

Our analysis shows that a primary component of SAR practice is *planning*, which is undertaken by individuals or teams to make decisions and synchronize effort [13]. During any planning process, information is gathered and analyzed from different sources to establish a strategy that leads to accomplishing a shared goal [4]. *Information seeking* and *sensemaking* are essential parts of SAR [13], through which responders collect, filter, and interpret information to develop a mental model of an overall information picture and collaboratively develop plans.

SAR practice involves a range of activities to support mitigating disasters. These activities are governed by rules of the National Incident Management System's Incident Command System (ICS) [15] and the local authority having jurisdiction (AHJ) [3], which guides the hierarchy of responsibility among responders and contributes to how labor is divided. SAR activities include assessing damage and needs—*reconnaissance* [4]; marking key locations; and constructing plans for physical search and rescue operations [3]. Information collected is communicated through maps [6, 12] that are shared, forming the basis of collaboration and planning "*we consult the map given to us by Incident Base, which outlines the search plan*" [P7]. Responders use a variety of methods for outdoor navigation and use different artifacts for planning (Figures 1, 2, 5) "*the backbone to effective search and rescue operations is a good foundation in backcountry navigation*" [3, p.104].

Initial Design Implications

The analysis of the data guided by the AT framework (Figure 3) helped uncover salient components of SAR practice that are relevant to the design of training systems. We suggest the design of interactive systems and training that simulate essential components of SAR work and practice:

Require Mixing of Individual & Collective Mapping. Systems need to enable both individual and collective activities to enforce the need for cooperative work, fostering social interaction, and learning how to establish common grounds. Information collected individually needs to be shared and combined to enable situation awareness and build effective plans, "*the co-op picture provide[s] a lot information [..] it shares the information from different mobile devices [..] and we are getting that feedback nearly instantaneously as well as pictures about what occurred, when, where, who*" [P2].

Require Mixing of Physical & Digital Mapping. Physical and digital artifacts are used interchangeably, thus, seamless transition between these artifacts is needed "*we went to Harvey, and some of that stuff [network] was down so we had to go back to the old method of pen and paper*" [P1]. Physical artifacts, such as paper maps, can be augmented using shared digital information [6, 10], to enable effective learning of different mapping and navigation methods.

Provide the Ability to Modify Maps. Systems need to enable the modification of maps and the ability to represent spatial information overlaid on top of maps "*key locations should be marked on the map*" [3, p.46]. Providing annotation interfaces (e.g., markers and waypoints (Figure 4)), help ground information in physical space [2], and support development of reconnaissance and sensemaking skills.

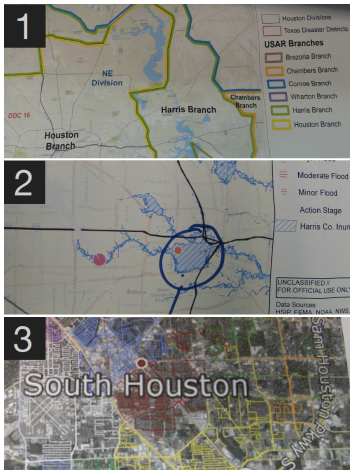

Figure 5: Maps of Houston, Texas from SAR operations during Hurricane Harvey. **(1)** The map is divided into multiple regions representing different districts. **(2)** The map shows overlay information of potential danger areas. The use of free-hand annotations is observed in the middle. **(3)** A map annotated with color codded GPS data representing the different levels of performed operations.

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Conclusion and Future Work

We conducted a qualitative study of SAR sensemaking and planning activities, which provided an understanding of current practices. Initial design implications for systems are presented. Our next step is to extend these findings and discuss them in depth, use them to inform the design of training systems, and test these designs in the field.

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