

# An Approach to Designing Next Generation User Interfaces for Public-Safety Organizations

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## ABSTRACT

High-speed broadband networks will enable public-safety organizations to handle critical situations that go beyond the common voice communication channel. In this paper, we present a user-centered approach that makes the deployment and adoption of next-generation user interfaces reflect the first responders' needs, requirements, and contexts of use. It is composed of four phases where we elicit requirements, iteratively prototype user interfaces, and evaluate our designs. In this process, public-safety organizations are always engaged, contributing through their feedback and evaluation. We will use immersive Virtual Reality to simulate the user interface designs. Within the virtual environment, it is possible to prototype several concepts before committing to a definitive interface. The solutions proposed will be instrumental for the adoption of next-generation user interfaces by the public safety community.

**Index Terms:** Human-centered computing—Human computer interaction (HCI)—Interaction paradigms—Virtual reality

## 1 INTRODUCTION

The current communication technology of first responders is evolving from Land Mobile Radio (LMR) to broadband LTE networks. In the near future, these high-speed networks will enable public-safety organizations (PSOs) to handle critical situations that go beyond the common voice communication channel. First responders from fire, EMS and law enforcement disciplines will have the opportunity to learn the precise location of indoor and outdoor points of interest, receive real-time data analytics that is relevant to the mission and have assurances for precise and reliable mission-critical voice communications, all through secure and resilient systems. All this technological advancement and the opportunities it brings to PSOs need to be developed into novel systems operated by the first responders. These systems demand user interfaces (UIs) that are effective and efficient, as they are engaged during critical situations.

In the context of public safety, it is important that risks are minimized. Thus, Virtual reality (VR) is an ideal tool to design, prototype and evaluate next-generation UIs, because prototyping directly into the target systems is not practical and could lead to undesirable risks. In VR it is possible to present realistic scenarios with highly immersive contents and natural interaction simulating the physical world. VR also makes it feasible to prototype several concepts before committing to definitive designs. Simulations can be repeated and tweaked as many times as necessary safely and with little effort.

While decades of research on VR user interfaces have been conducted, most investigation has been limited to lab experiments in highly controlled conditions. The reality of public safety is different in that it involves complex scenarios with many factors at play. The

successful adoption of novel user interfaces relies on a clear understanding of first responders needs, requirements and contexts of use. We posit that a feasible way to design, prototype and evaluate user interfaces for the next generation public safety ecosystem and its first responders is to partner with public safety organizations. This way, we can fully understand their processes, identify opportunities for new interfaces and collect formative feedback during the design stages. First responders are also ideal users for the formal evaluation of the proposed prototyped UIs. The designed Public Safety User Interfaces (PSUIs) will be instrumental for the adoption of next-generation user interfaces by the public safety community. PSOs and industry providers will be able to leverage the materials and methods created by us to extend or advance future public safety processes, standards, protocols, equipment and systems.

## 2 METHODOLOGY

We propose an approach focused on user-centered design principles [4]. Our approach contains four development phases: (1) requirement analysis, (2) prototyping and evaluation of interaction techniques for PSUIs, (3) prototyping and evaluation of comprehensive PSUIs, and (4) prototyping of a cross-discipline PSUI.

We iteratively design each phase in cycles that involve prototyping, testing, analysis and design refinement through our partnership with PSOs. Law enforcement officers, firefighters and emergency medical services first responders will contribute through their feedback and experience. This way, we can fully understand their processes, identify opportunities for new interfaces, collect formative data and conduct formal evaluations of the proposed prototyped UIs to advance the knowledge necessary towards a comprehensive public-safety next-generation user interface.

Each phase is detailed below:

1. **Requirement Analysis:** The goal of this phase is to fully understand the PSOs processes with an aim at establishing the opportunities for which user interfaces that rely on next-generation technology can be designed. Thus, field research with PSOs collaborators, following the principles of applied ethnographic [3] along with training and operations observations are the main activities in this phase (Fig. 1a). Our requirement analysis is strongly based on the research by Choong et al. [1], which is probably the most comprehensive source of information on requirements raised by PSOs. In our case, we are working with a small group of first responders that are available for interviews, groups meetings and experiments. We expect to identify problems that are deemed as essential by PSOs and cross our collected data with the results reported in [1].
2. **Prototyping and evaluation of interaction techniques for PSOs:** After understanding the critical tasks for each public safety discipline, we will implement UIs that aim specifically at addressing the identified demands. This phase includes travel and selection tasks in VEs [2] in the context of critical elements for each public safety disciplines. We will, thus, prototype the user interface elements, including displays, widgets

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Figure 1: Overview of the user-centered approach created to make the deployment and adoption of next-generation user interfaces reflect the first responders' needs, requirements, and contexts of use.

and sensory feedback that are relevant for the completion of the identified task. For example, we may discover that firefighters can benefit greatly from a heads-up display during the operation of a fire hose, as their hands are occupied. We will, then, implement a task that needs to be performed with support from the HUD. In the fire-hose example, the HUD may indicate that there is a new focus of fire, and the prototyped UI will require travel to the fire location, as well as the selection and manipulation of the fire hose. The main goal of this phase is to establish when it is preferable to use a high-fidelity natural interaction technique (see Fig 1b), and where a magic technique may increase efficiency without a detriment to the simulated exercise experience.

3. **Prototyping and evaluation of comprehensive PSUIs:** In this phase, we will use the findings from phase 2 as input in the design of comprehensive UIs for fire safety, EMS and law enforcement. These UIs will combine most effective interaction techniques for the tasks of travel, selection and manipulation with next-generation cognitive aids for enhanced situational awareness and wayfinding to improve overall public safety discipline protocols (Fig. 1c). While phase 2 will look into objective performance components of the task when performed under simulated environments, phase 3 UIs will focus on cognitive components of the first responders' tasks under simulated next generation technology. For the UIs designed in this phase, we will incorporate the highest rated interaction techniques from phase 2, and we will simulate tools available with next-generation technology. These UIs will include simulated AR, with heads-up displays and tactile vests, to incorporate situational awareness and wayfinding tools into UIs.
4. **Prototyping of a cross-discipline PSUI:** The goal of this phase is to design a VE for a critical situation that needs a response from fire, EMS and law enforcement (Fig. 1d). First responders from each discipline will engage in the simulation and coordinate through voice communication and cognitive aids for situational awareness and wayfinding.

## 2.1 Technical Approach

We will use two main VR platforms to evaluate the user interface prototypes: a CAVE system and head-mounted displays (HMD). CAVEs are highly immersive room-sized projection-based virtual reality system where users are physically and visually immersed in the virtual environment. HMDs are the current state-of-the-art for virtual reality, as it allows for room-sized tracking while being

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reasonably-priced and widely available, which is consistent with the reality of many PSOs. As interaction hardware, we will use consumer-grade tracking systems, such as the HTC Vive Lighthouse tracking system both in the CAVE and the HMD. This tracking system is robust and can ensure consistency of tracking across setups.

## 3 DISCUSSION AND NEXT STEPS

We proposed a user-centered approach where we explore PSOs collaboration to maximize the acceptance of the proposed interfaces. First responders' expertise and opinions are essential when considering the design, development, and adoption of new technology. As pointed by Choong et al. [1] new technologies need to solve PSOs' real problems and not add another layer of complexity in their workflow. Our approach has four phases that start with requirement analysis and end with solutions for cross-discipline public safety UIs. To effectively advance through the phases, we refine the prototypes with an iterative design that goes from low to high fidelity and perform formal evaluations to collect the first responders' feedback.

We are applying the approach presented in this paper with three Public Safety Organizations: a police department, an EMS station and a fire department. Our initial interviews, meetings and training observations revealed that PSOs are enthusiastic about the benefits that next generation UIs can bring to their work environments.

Ultimately, this project aspires to offer validated PSUIs with potential for implementation in the real world. For that reason, all materials derived from the project will be provided in the public domain. To facilitate access, we will deploy the "Public Safety User Interface Resource Library," an online repository where all gathered knowledge will be publicly available. PSOs and industry providers will be able to leverage the materials and methods used in the design, prototyping and evaluation of next-generation user interfaces.

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