# Conducting Human-Robot Interaction Research during Three Real World Disasters

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Unmanned ground, aerial, and marine robots have been used at disasters, public safety incidents, and other non-routine (off-normal) events since 2001, when they were used during the response to the 9/11 World Trade Center disaster. One of the major benefits of using unmanned robotic systems is inherently that the human does not have to be in the dangerous areas of the disaster, however, it does not remove the need for the human. Therefore it is useful to have human-robot interaction data from actual disasters. However, it is difficult to get access to collect research in the field with the actual responders during an event; and, once embedded with responders, there are few established protocols for collecting quantitative data as part of a disaster response with robots. As part of an effort to identify the unique needs and risks that disaster robot operators experience, the Center for Robot-Assisted Search And Rescue (CRASAR) collaborated with researchers from Occupational Health and Industrial Engineering to imbed participant observers and have them document the experience of small unmanned aerial systems (sUAS) pilots during disaster response for three disasters: Hurricane Harvey in 2017, the Kilauea volcanic eruption in 2018, and Hurricane Michael in 2018.

This paper documents those events and specifically our efforts to collect quantitative data on sources of pilots stress and fatigue; assess fatigue; and identify how fatigue changes over the course of a mission for sUAS pilots and the response teams. We describe lessons learned regarding methods for how to best collect data in this dynamic field setting. In particular we describe:

- Ethical considerations in embedding with response teams; that HRI researchers may not be able to work with responders in the field because of personal risk and accountability for non-essential personnel,
- Ergonomics of wearable measurement devices; that common wearables may be uncomfortable especially in outdoor heat for 12-15 hours or may interfere with wearing wristwatches or other gear,
- Impact of measurement methods on workflow; that responders are unlikely to remember to perform data collection steps for HRI in the field because it is not part of their normative routines, nor willing to complete lengthy surveys or interviews, measurement processes, or self-assessment activities that interfere with the normal post-mission routines of data processing, equipment maintenance, and personal rehabilitation time, and
- Instances where self-reporting may not be useful without additional context; the pilots may report ergonomic or usability issues but those may be indicative of training.

We specifically provide descriptive information for each of the three events regarding the response team and the unmanned vehicles they were using; attributes of each disaster; methods used during that disaster; and adaptations made to the methods based on the pilots' and researchers' experiences during the disaster. We conclude with recommendations based on the experiences of the researchers and sUAS pilots.