Assessment of Human and Multiple UAVs Interaction in Police Clearing Operations

by

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A thesis submitted to the graduate faculty

in partial fulfillment of the requirements for the degree of

Master of Science

Major: Industrial Engineering

Program of Study Committee:
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The student author, whose presentation of the scholarship herein was approved by the program of study committee, is solely responsible for the content of this thesis. The Graduate College will ensure this thesis is globally accessible and will not permit alterations after a degree is conferred.

Iowa State University

Ames, Iowa

2020

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ACKNOWLEDGMENTS

I would like to express my deepest thanks to my major professor Dr. Richard Stone who offered me the opportunity of my master's program, supported me in my research, guided me, and showed the path of my career.

Special thanks to my committee members Dr. Min and Dr. Li. I understand this is a hard time due to the COVID-19, but you supported me through such a difficult period with your encouragement and wisdom.

I would also like to thank all the ATHENA Lab members for their help and company and thank Erik Danford-Klein, Colten Fales, and Fatima Mgaedeh for your emotional support and thesis consultancy.

Besides, I would also like to thank the department faculty and staff for giving me the greatest Iowa State University adventure experience in Ames, Iowa.

Last, thank you, my beloved parents, Hengjian Xu and Hui Yan, for your unconditional love and support.

ABSTRACT

Unmanned aerial vehicle (UAV) or drone technology is developed maturely these years, and drone assists humans in various fields. Especially, it is a great solution for law-enforcement operations. Officers usually work individually or with a small group during the clearing operation, which may encounter uncertain events or surprising ambush from the hostile target and respond to the potential threat swiftly and appropriately.

An assistant drone can support law-enforcement officer has the potential to increase the safety and reduce the number of casualties by detecting and spotting hostile target in advance during the operation. Drone swarms (multiple UAVs) are more efficient than a single drone in the searching process, and swift clearing operation means less possible injuries. Hence, this study is aiming to find an effective and intuitive single operator interface for multiple swarm law-enforcement operations based on the previous study. In a simulated environment, this study reconducted single monitor single drone trails as the benchmark, and both of single monitor swarm and multiple monitors swarm trailed are tested against each other and are assessed their effects on cognitive workload. The cooperation time and target identification are recorded, and officers completed a survey that included adjusted NASA-TLX survey, modified SART survey, and informal interview questions to determine the optimal setting.

Although the result showed single monitor swarm is more complex and uncomfortable to use, the target identification result proved single monitor swarm is a stable and safe interface setting with smoother operating pace. According to the informal interview, participants have no complains and are willing to work with drone in the future, but they suggest a mature and implemented drone technology in the future, so the drone or drone swarms can be a part of puzzle of clearing operation in the future.

CHAPTER 1. INTRODUCTION

Unmanned aerial vehicles (UAVs), also known as drones, are a pilotless flying object that can operate through autopilot or can be controlled by a human operator. Some are small unmanned aircraft (sUAVs or drones) “weighing less than 55 pounds on takeoff, including everything that is on board or otherwise attached to the aircraft (Federal Aviation Administration).” According to the United States Federal Aviation Administration Title 14 Part 107, these small UAVs are designated as “sUAVs” and will be labeled as such in this thesis, whereas “UAV” indicates any craft larger than 55 pounds. In aviation history, the first vehicle with no on-board crew or passenger was made in World War I. Other such unmanned aero craft like cruise missiles paved the way to allow UAVs technology to evolve rapidly through World War II and the Cold War. During these periods, the UAVs developed abilities to deliver real-time information, detect designated targets, assistant frontline troops, and assault the enemy with on-board weapons (Blon, J.D, 2010).

Although UAVs have been successfully applied and deployed in the military field since the 1910s, at the civilian level, the UAVs were not fully developed due to the current limitations of UAV technology and the lack of communication between humans and the UAVs. Currently, the consideration of safety is the primary problem, such as potential collisions of UAVs hitting unmanned or manned flying objects (like airplanes) and ground targets, (like humans and property) (Stephen, B. H, 2015). However, in the last decade, UAVs technology has improved rapidly due to the advantage of drones. Because the UAVs can quickly respond to the orders to search certain areas, deliver support, and feedback real-time massage with limited operator exposure to the hazards and risks (Greenwood et al., 2020).

However, in the last decade, UAVs technology has improved rapidly thanks to the

advantage of drones. UAVs can quickly respond to the orders to search certain areas, deliver support, and feedback real-time massage with limited operator exposure to the hazards and risks (Greenwood et al., 2020).

Due to the characteristics, the UAVs can be suitable tools for the law-enforcement agency to deal with a wide variety of situations. Though a helicopter can achieve the same tasks as drones do, the material and operating costs of a helicopter are significantly higher. According to the U.S. Department of Justice data, the average price of the helicopter is near 30 times more than the cost of sUAV, and the average operating and maintenance cost is near 16 times more for the helicopter than for the cost of sUAV (Valdovinoset al., 2016). Besides the cost, the applications of sUAV are a versatile tool and sUAVs can assist operators under multiple situations when the helicopter's strength is limited because drones not only can be operating in natural disaster rescuing, heavy snowfalls and strong winds searching, but also can locate building firefighter, police, hostage, suspect, and terrorist in a building or a room (González-Jorge et al., 2017).

(Further, law enforcement care about more than costs and technological advancements) .Specifically, law enforcement agencies are urged to have a safer approach to execute building clearing operations by using drones in the form of sUAVs. The objectives of building clearing operations are occupying critical areas as footholds for further actions, determining inimical objects and friendly targets, eliminating threats with minimum force, and evacuating personnel equipment. During these processes, under a high-stress environment, law enforcement agencies face dangerous and uncertain situations and require not only physical preparation but also mental concentration (Texas Association of Police Explorers, 2004). To reduce the potential injuries of law-enforcement agencies that many may face, drones are an optimal solution for the police

department to deal with low budgets, limited human resources, and temporary operator's loss. Since the implementation of drone technology, drones exhibit the capability to capture detailed images and search large areas (Hernandez et al., 2014), cooperating with other drones (Hernandez et al., 2014), and autopiloting within an indoor environment (Mac et al., 2018). Despite the advancement in drone automation, there are few research studies focused on law enforcement application, and, explicitly, building clearing operations. Although the related human-robot interaction research was developed in the military, in Chen et al. (2008) study, the military-purposed UAV interfaces were examined through the NASA Task Load Index (Hart & Staveland, 1988) and a Simulator Sickness Questionnaire (Kennedy, Lane, Berbaum, & Lilienthal, 1993). The result shows one of the problems of the human-robot interface that multiple asset workload is statistically higher ($p < .005$) than a single asset workload (Chen et al., 2008). The study is limited to the military-purposed, outside, and long-range distance drone simulator. The uncertain and uncleared indoor situation causes blind spots during the clearing operation. The potential hazards and lethal ambushes threaten the lives of the law-enforcement officers (Greenwood et al., 2020). To solve the indoor hazards of law-enforcement clearing operations, Schnieders et al. (2019) tested a single drone to support the law-enforcement agencies in a simulated building clearing operation. Schnieders et al. (2019) argued that, due to the improvement of microchips of drones, drones are able to move indoor environments with high quality of streaming and maneuverability capability; drones fit into law-enforcement clearing operations. Their research shows that a single operation drone provides clearer target information without a law-enforcement agency present in the designated room physically. Schnieders et al. also indicate that the mental workload of law-enforcement has no negative influence with fewer targets missing in the simulated operation area. More importantly, the study

showed 0 missing hostile target in drone assistance among all the participants (Schnieders et al., 2019). The result is crucial because the safety is the most considered factor in the clearing operation.

On the other hand, because of the improvement of the cutting-edge drone technology, it is now possible to control multiple UAVs in a tight formation as a single drone swarm. Multiple drone swarms are more capable of clearing large areas, simultaneously, with less amount of fuel and time (Jones et al., 2010). In theory, with the approachable method, drone swarms are able to autopilot and auto-search to complete the objectives and cooperate with other UAVs in the swarm (Kunming et al., 2020). Faster searching speed is critical in clearing operation, because less operation and reaction time means less injuries (Hontz, 1999).

A problem with utilizing drone swarms is the cognitive load when an operator uses more than one drone at a given time. Due to the characteristics of drone swarms, as mentioned by Chen et al., the operator of drone swarms receives information and executes the orders instantaneously and continuously. The result of this mental workload is significantly higher than the workload of watching a single asset (Chen et al., 2008). The study verified by Dixon et al. (2003) demonstrated that an individual has a higher fail rate when controlling two or more robots at the same time (Dixon et al., 2003; Roldán et al. 2017). In operation, the operator collects the data from the drones, interprets and decodes the data by accessing the interface. Next, they would have to make the decision, and commanded the drone through interface order. Suitable interface and auxiliary instruments can help reduce the mental workload during the multiple UAVs operation (Roldán et al., 2017).

Although studies have indicated that the NASA-TLX score is an engineering approach which can provide the quantitative and qualitative information (Chen et al., 2008; Dixon et al.,

2003; Roldán et al., 2017), however, this information is limited and narrowed as they don't take into account the direct feedback from the participants. By following human-centered design, participants' needs are one of the primary objectives for satisfactory design. As implementation of human performance design principles, the interface should support the users' normal and "flexible multimodal communication pattern", minimize the mental workload, and align with users' real work training (Oviatt, S., 2006).

In human-computer interaction, another key factor is the trust between humans and computers. In the book, *Engineering psychology & human performance*, the study mentioned the trust between human and computer influence the users' reactions with the information from the system (Wickens et al., 2000). This study showed that trust can affect the performance of human-machine interaction, especially in the case of fully automated machine work This study also mentioned the human-human model presented by Rempel, Holmen & Zanna (1985), and extended it to human-machine model. The human-machine model presented the user as a "supervisor" of the machine and verified there was a relationship between human-machine interaction. In Rempel, Holmes & Zanna (1985) model, a human-human trust system was created based on predictability (dominating in the early relationship), dependability (dominating in the later stage of the relationship), and faith (dominating in the "mature interpersonal relationship").

Furthermore, Muir (1994) indicated the dynamics model of trust, which was adopted from Rempel, Holmes & Zanna (1985), was related to the work experience of the machine operator. Muir's (1994) also mentioned that providing examples can increase the trust between humans and machines. However, empirical tests were lacked (Muir, B. M., 1994). Later, Hancock et al. (2011) pointed out human-related factors, robot-related factors, and environmental factors which are factors of human-computer trust. The study was an empirical

analysis that considered and provided 69 correlational and 48 experimental studies through meta-analytic methods. The results of Hancock et al. (2011) showed robot-related factors and environmental factors were affected and associated with trust. Moreover, little evidence showed that the human-related factors were associated with trust. This study proved dependability and predictability which affect the trust between humans and machines from Muir (1994) human-computer trust model. The Muir's model was adopted from Holmes & Zanna (1985) human-human trust model. Instead of engineering approaches to access the interface interaction between humans and UAVs, it is critical to ask the special group of the users' opinions and to learn the focus groups of users' communication patterns. In this study, we addressed this problem by conducting informal interviews with each law-enforcement officer to better understand different scenarios. Through the interviews, the trust related topic questions are covered.

The previous studies investigated the optimal solution of multiple UAVs supporting highly trained law-enforcement agencies in building clearing operations while focusing on the effectiveness of clearing. This was accessed by operator feedbacks in three different scenarios: (1) single monitor single drone, (2) single monitor swarm, and (3) multiple monitor swarm.

The NASA Task Load Index (Hart & Staveland, 1988) and the Complexity score of Situation Awareness Rating Technique (Taylor, R. M., 1989) were recorded and analyzed from each situation: (1), (2), and (3). A modified Trust Perception Scale-HRI (Schaefer, 2016) was used to access the factors which affected the trust between human and drones.

The goals of this study were to discuss the trust issue through informal interviews and to verify [1] single monitor swarm and multiple monitors swarm required same mental workload as single monitor single drone; [2] by accessing results of the experiment, the single monitor swarm is the optimal interface setting.

CHAPTER 2. METHODS

2.1 Participants

Participants were trained law-enforcement officers and had the ages between 22 to 63 (M = 33.0, SD = 12.7). The participants served as law enforcement officers with experience ranging from one to 43 years (M = 6.1, SD = 13.0). The participants' clearing operations training experience was around one to 43 years (M = 6.0, SD = 13.0). There were ten participants in total. Six out of ten participants conducted a real clearing operation. Eight out of the ten participants were male, and two out of the ten participants were female. Participants completed 40 runs of the experiment in total, and each performed four runs.

2.2 Equipment

The setting of the drones, which recorded the videos, was quadcopter and the weight was around 80 grams and each contained an 82.6-degree field view with a 720p HD transmission capacity camera. The camera features 5-megapixel (2592 x 1936) photos. The size of the drone is 3.9 in x 3.6 in x 1.6 in, and the max speed is 8m/s. See Figure 1 below.

Figure 1. Experimental Drone

Multiple standard 24-inch monitors were used in accessing the pre-recorded video from drones.

2.3 Setting

The scenario started with the participant who took the role of a regional law-enforcement officer. The test environment was formed by a looped hallway, and seven individual rooms off the main hallway, as Figure 2 shown below. Each room was furnished, and all participants were made familiar with the building and inside layout before the experiment. In order to randomize the study, the in-room objects were differentiated after each designated session.

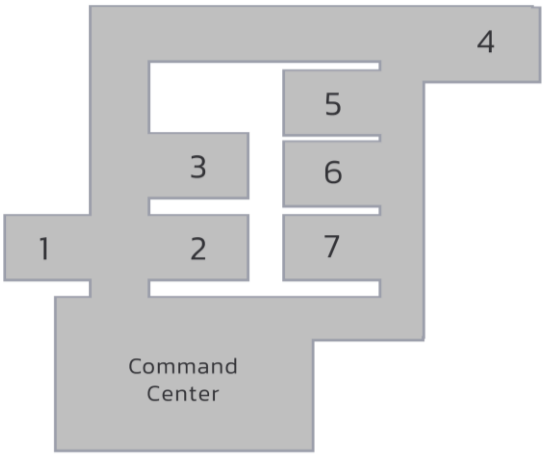

Figure 2. Layout of the experimental setting

2.4 Experimental Procedures

Upon arrival, the participants were asked to complete an informed consent form and a pre-survey. This survey was to find information about the previous experience related to building clearing operation, drone operation, and personal demographic information.

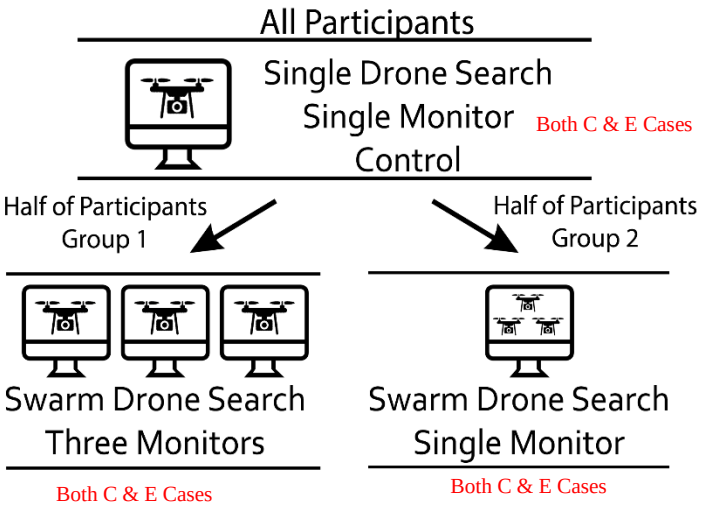

Figure 3

Figure 3. Procedure of the drone study

Firstly, each participant watched two pre-recorded single-drone feed videos separately by using a single monitor. A video was recorded by the control group, and there were no targets hidden or covered in any of the rooms in the footage. Another video was recorded by the experimental case where a target was hidden or covered in a random room, and the subject had difficulty in detecting the target. Participants were instructed to call out if they found a target and marked on a printed map of the experimental area if they confirmed the target was found. Participants were asked to finish the full video even if they already found and marked a target on the map. If the participants did not find and mark any target, they were informed to mark the “No Target” on the post-survey.

After the first two videos were completed, half of the participants were assigned to the multiple monitors with a single drone feed group, and half of the participants were assigned to the single monitor with multiple drones feed groups. Both groups had a control case and an experimental case. In the multiple monitor group, the participants were asked to watch three monitors at the same time, and each monitor was feeding the video from separated drones. There were two runs in the three monitors with a single feed experiment, and the participants were instructed to mark the target if they saw a hostile target, or they marked "No Target." As with the multiple monitor group, the participants were asked to watch a single monitor with three feeds simultaneously and marked target or "No Target" after the videos were completed.

All the videos were filmed and pre-recorded in the same building as shown in Figure 2. The reasons of pre-recording is because we try to eliminate variables in the videos, so participant would watch same The drone operator watched the recorded video. And, in the video, the drones were followed the command verbally by the lead officer who presented in the video. The drone entered each room and scanned the room, no more than 40 seconds, and then the officer followed the drone. The lead officer held an orange "bluegun", which is a plastic pistol, and the officer and drones, as a group, searched the rooms in the designated building, as Figure 4 shown below.

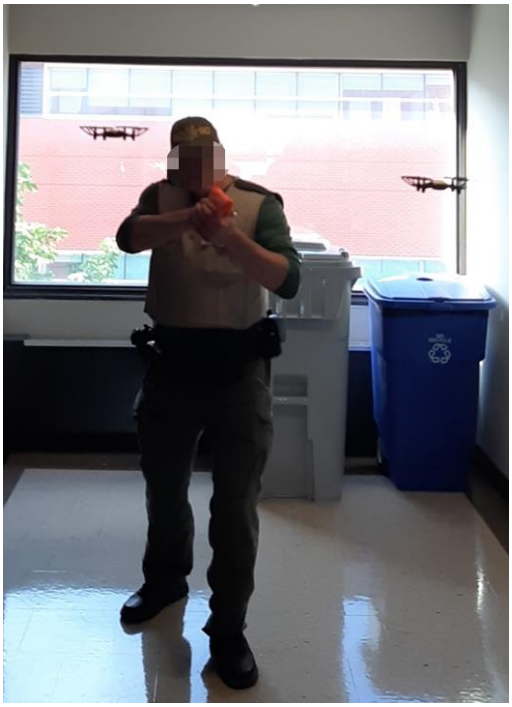

Figure 4. Lead office sending a command to drone operators and corporate with drones

In the experiment, the participant is the lead officer who can access the videos from drones and make the decision to call out and mark the target. In a real-life scenario, the lead officer will watch the drones' feeds, so missing a target will cause a potential hazard to all law-enforcement officers present.

After finishing four runs, each participant was asked to complete a post-survey, which includes modified versions of the NASA-TLX Index (Hart & Staveland, 1988) and the Complexity score of SART.

2.5 Assessment Tools

The NASA-TLX Index:

An assessment tool of mental workload allows the users to self-evaluate subjective performances when humans are interacting with the machines' interface system. The score is based on the weighted average of six subcategories, which are mental demand, physical demand,

temporal demand, frustration, effort, and performance (Hart & Staveland, 1988). NASA-TLX is generally used in various industrials, which involved with a human-machine interface such as spaceship control (Zhang et al., 2009), planes interface (Yiyuan et al., 2011), construction machine (Akyeampong et al., 2014), etc.

Situation Awareness Rating Technique:

The SART is a situational awareness assessment tool that can evaluate the situational awareness from seven aspects: complexity, alertness, concentration, division of attention, information quality, familiarity, and spare mental capacity (Taylor, R. M., 1989).

Although situation awareness information can be provided through the SART to us, we try to narrow the scope of the study, because a complex interface would cause a problem in clearing operation.

2.6 Dependent and Independent Variables

Dependent Variable:

- Correct/incorrect target (error) calls in each trail
- Operation Time
- NASA-TLX survey score
- SART Complexity score

Independent Variable:

- Number of Monitors
- Number of drone feeds on each monitor

For the study, the recorded videos were randomized by orders which certain videos were not presented again and making sure the videos were distributed and watched evenly among participants. This order ensures no-bias present among the recorded videos and allows all variables were performed by each participant.

CHAPTER 3. RESULT

3.1 Target Identification & Time Difference

40 rounds of this experiment were conducted in total. Participants located, called out, and marked a potential target in a specific room correctly within 35 runs. In total, there was one run where the participant failed to find any targets in any room, and there were four runs with misidentified targets where participants located and marked a target in a different room from where the target was located. Half of the runs were using a single drone. Only two out of 20 runs, occurred where the participant marked the target in a room incorrectly, with 10% error rate in total. In the single monitor swarm, which were 10 runs in total, there was one incorrectly identified (type I error, marked target in a wrong room)target, with 10% error rate in total. In the multiple monitors with single drone feed trails which were 10 in total, there was one incorrectly identified (type I error, marked target in a wrong room), and one was a completely missing target (type II error), with 20% error rate in total.

In time difference, single drone required average operation time is approximated 5 times as multiple drones (three drones) average operation time.

3.2 NASA-TLX score

Each catalog was computed individually by using the one-way ANOVA single factor analysis ($\alpha = 0.05$) to other trails. Both single monitor and multiple monitors swarm are comparing to the single monitor and single drone. The summary of each catalog is showed in Table 1.

Table 1. Summary of all the ANOVA F-test of each catalog

	Mental Workload	Perceived Difficulty	Pace of Task	Insecurity Stress	Complexity
Single Monitor Swarm	p=.0273 < .05 **mean> single drone**	p = .0003 < .05 **mean> single drone**	p = .0992 > .05	p = .1589 > .05	p = .0085 < .05 **mean> single drone**
Multiple Monitors Swarm	p=.2659 > .05	p = .0060 p < .05 **mean> single drone**	p = .0357 p < .05 **mean> single drone**	p = .9106 p > .05	p = .1389 p > .05

3.2.1 Mental Demand

By using ANOVA, the results showed that using a single monitor with multiple drones' feeds is more mentally demanding than looking at a single monitor with a single drone feed [$F(3,16) = 3.966$, $p = 0.0273$]. However, there were no statistically significant in mental demand between looking at a single monitor with single drone feed and multiple monitors each with single drone feed [$F(3,16) = 1.449$, $p = 0.2659$].

3.2.2 Perceived Difficulty

The results showed that using a single monitor with multiple drone feeds is more difficult for participants to perceive than looking at a single monitor with a single drone feed [$F(3,16) = 11.679$, $p = 0.0003$]. Unlike the mental demand result, there were statistically significant in

perceived difficulty between looking a single monitor with single drone feed and multiple monitors each with single drone feed [$F(3,16) = 6.020$, $p = 0.0060$] which means looking at multiple monitors feeds is more difficult than watching a single monitor with single drone feed.

3.2.3 Pace of Task

The results presented that participants perceived in a more rushed pace when the participant was watching the multiple monitors with single drone feeds compared to the single monitor with single drone feed [$F(3,16) = 3.636$, $p = 0.0357$]. The results also suggest that the single monitor with multiple drones' feeds is not a statistically significant $\alpha = 0.05$ threshold but something different [$F(3,16) = 2.471$, $p = 0.0992$].

3.2.4 Insecurity Stress

Results suggest that insecurity and stress had no statistical significance between both the single monitor with multiple drone feeds, compared to a single monitor with single drone feed [$F(3,16) = 1.972$, $p = 0.1589$]. Same as the single monitor with multiple drones' feeds, there was no statistical significance between multiple monitors with single drone feed and single monitor with drone feed [$F(3,16) = 0.177$, $p = 0.9106$].

3.3 Complexity score of SART

Table 1 showed the calculated scores of the Complexity score of SART. Although SART is different from the NASA-TLX and even overlapped each other on some level, the situation awareness complexity is the only catalog that was assessed by using the one-way ANOVA single factor analysis ($\alpha = 0.05$) to other trails.

3.3.1 Complexity

Results suggest that looking at a multi-monitor swarm feed is more complex than watching a single drone feed [$F(3,16) = 5.529$, $p = 0.0085$]. There was no significant correlation found in complexity from viewing multiple monitors swarm feed compared to a single drone feed [$F(3,16) = 2.160$, $p = 0.1327$].

3.4 Informal interview

Based on survey and interview, law enforcement generally loath to trust the drones due to the general trust, which is between human, and robot limitations of drones, although they agreed about drones can deliver clear and accurate information in each unsearched room. One participant mentioned that, “I think there were circumstances where maybe we would've wanted more of an angle or like a lower angle to...” Seven participants mentioned the camera angle limited the version of the search area which they want a wider angle to expend the vision.

In terms of the comfort level of working with drones, seven officers mentioned that they do not have enough experience or any related training with drones or cooperating with drone operators. Four officers out of the seven officers suggested that they are preferring work with a human, for example, additional officers or drone operators. One participant said, “I would rather have a second person than a drone, but if it was just me and someone else running the drone, I’d rather have the drone than just be alone…”

Automated drones were not trusted among participants. Five participants suggested that they preferred a drone operator to help rather working with a fully automated drone. One mentioned about working with automated drones but with a drone operator who can supervise

the automated drone, and the participant said, “You’re losing a set of eyes… you’re just trusting a computer at that point, not another person. So, I'd probably feel more comfortable with a person [at] the end of it, not a computer."

Generally, officers preferred to use a drone or drone swarms to search over a large and open area or high places. One participant mentioned that using a drone or drone swarms is a safer way to complete the clearing building operation, and said, “You can see the majority of the room and see that nobody is in there, and then I can go check the smaller spaces…. A lot safer than somebody just standing in the middle of the room, and as soon as I come around the corner, they’re shooting at me.”

CHAPTER 4. DISCUSSION

The study focused on the discussion of trust between humans and computers and verified two hypotheses: [1] single monitor swarm and multiple monitors swarm required same mental workload as single monitor single drone; [2] by accessing results of the experiment, the single monitor swarm is the optimal interface setting.

According to the result of NASA-TLX, hypothesis [1] was tested by this study's result, where a single monitor with multiple drones feeds mental workload was statistically significant different [$F(3,16) = 3.966$, $p = 0.0273$] comparing single monitor with a single drone feed. There was no statistically significant mental demand score difference between participant looking a single monitor single drone feed and multiple monitors swarm [$F(3,16) = 1.449$, $p = 0.2659$]. Our study verified that single monitor swarm would increase the mental load of the operator during the clearing operation. For a single monitor swarm, the result is the same as the previous studies' findings (Dixon et al., 2003; Chen et al., 2008; Roldán et al., 2017).

However, interestingly, in the case of single monitor swarm, even participants think they require a higher mental workload. The target identification has no difference from the result of single drone. Both setting had a 10% error, and both were type I error.

In the opposite way, multiple monitors swarm not require a higher mental workload but had a 20% error rate with 1 type II error. The type II error is unacceptable because this means a potential injury or death for a or even more law enforcement officer in clearing operation.

There are a few potential reasons that could cause additional cognitive overload. Firstly, in a high-stress circumstance, such as clearing operations, the participant needs to send the commands to drone swarms, to perceive the information from drones, to make decisions, and to cooperate with sUAVs. During this process, participants can be easily distracted and tend to miss

important details. This leads to the result of the target identification test because at less one misidentification or missed target in both drone swarm cases. Although we followed the procedures in the same environment setting as the previous study, the first reason explained why the result difference. Our result also aligned with the results of Dixon et al. (2003), as their study mentioned, the operator's performance declined after the operator commanded two robots or more. Secondly, although law-enforcement officers can send the command to the drones, the law-enforcement participants were not trained on how to collaborate with drone swarms before. Since this was the first time the participant used the drone swarm in the clearing operation, the participant required additional cognitive load to cooperate with the drones. This reason can be applied to all the trails. Thirdly, a lousy interface layout would require an extra mental load. Chen et al. (2008) suggested the current system in their study, which has a poor interface setting, and participants usually had saliency effects and the anchoring heuristic. This explained why participants thought about looking at a single monitor with multiple drone feeds that required high mental demand because participants would choose a feed as the main screen or focus and would miss the detail in the other two feeds. Additionally, they would prefer multiple monitors due to participants treating each monitor separately rather than one monitor, and eliminating the saliency effects and anchoring heuristic. This could explain why multiple monitors swarm, even with less mental workload, still has one type II error.

Nevertheless, although the multiple monitors swarm showed no statistically significant difference in terms of mental demand, the target identification result had one type II error. This may due to the saliency effect that mentioned previously. Notably, type II error is very dangerous in law enforcement clearing operation.

The result of the perceived difficulty of both cases showed statistically significant

difference. This means multiple monitors swarm feeds [$F(3,16) = 11.679$, $p = 0.0003$] and single monitor swarm feeds [$F(3,16) = 6.020$, $p = 0.0060$] were harder to perceive than a single monitor with a single drone feed. Both of single monitor swarm feeds [$F(3,16) = 1.972$, $p = 0.1589$] and multiple monitors swarm feeds [$F(3,16) = 0.177$, $p = 0.9106$] showed no statistically significant difference in irritation/stress.

Although the perceived difficulty is higher in both swarm groups, the error rate of single monitor swarm is same as the multiple monitors swarm with same insecurity/stress level.

Besides, participants' self-rated pace of task results showed no statistically significant difference [$F(3,16) = 2.471$, $p = 0.0992$] when using the single monitor swarm feeds. On the contrary, the results showed for the multiple monitors swarm feeds [$F(3,16) = 3.636$, $p = 0.0357$] showed a statistically significant difference compared to single monitor with a single feed. The results of the Complexity score of SART showed that watching single monitor swarm [$F(3,16) = 5.529$, $p = 0.0085$] is more complex than watching multiple monitors swarm [$F(3,16) = 2.160$, $p = 0.1327$].

As the results mentioned, since both single monitor swarm feeds and multiple monitors swarm, feeds are harder to perceive, but both have the same stress or frustration level as single monitor single drone.

With regard to the hypothesis [2], although the single monitor swarm is more complex and uncomfortable to us, even require additional workload, in terms of target identification result and pace of work, a single monitor swarm is the preferred interface setting. This due to the type II error that occurred in the multiple monitor swarm group. In the clear operation, a complete miss a target usually causes the injury and even death.

In addition to the quantitative analysis, informal interviews provided us more

information. In the direct feedback from the participants, there was no one complained about the drone assistance in the clearing operation, and they were looking forward to working with drones. However, they had their considerations and comments about how drones should be changed to suit the clearing operation. Some participants worried about the information and feedback back and forth between participants and drones, especially fully automated drones. Due to the current drones and human interaction model, communication is a big problem that is related to the topic of dependability and predictability. According to Hancock et al. (2011), dependability and dependability and predictability are critical robot-related factors in human and machine trust. These two factors represented the reliability of robots based on the robot's capability. In the study, instead of giving feedback from the drones, the participant had to perceive the images/footage from the drones' feeds. After receiving the feedbacks, participants should decode the image, which basically is analyzing the video, making the decision, and sending the next command to the drone. This pattern was mentioned in Hocraffer and Nam (2017). This is different from human and human interaction because law enforcement would communicate the feedbacks through the language directly. The law enforcement officer who received the information verbally does not need to decode the image but gets the decoded information from the law-enforcement officer who detects the room and sends the feedback to him/her. To conquer this question, self-detect drones would be a solution for the future due to the capability of decoding the image and sending it to the officer directly, a concept developed by Cooper and Goodrich (2008).

Besides the technical issue, in the informal interview, training is another reason which caused the potential problem between human and drone. Seven officers mentioned that they would be better trained or had experience with the drone before the clearing operation. As Chen

et al. (2008) mentioned, since there was no related training before, the law-enforcement officers would follow their own communication pattern rather than a new path. An inefficient communication was made through lack of training, and, consequently, the dependability and predictability of the drone swarm were decreased, so an untrusting relationship was formed. However, all feedbacks are positive because the suggestions showed law enforcement officers who are willing to build the bridge between officers and drones towards future clearing operations.

In addition, in a Hancock et al. (2011) study, the environment was another factor which majorly influenced the trust between human and drone and was verified through the experimental and empirical analysis. In this study, the building was a familiar building for all the participants, so the physical environmental factor would help form trust between participants and drones. Curiously, environmental factors, mentioned in the Hancock et al. (2011) study, contained culture, communication, and shared mental model as sub-factors. Although personal training is human-related, it did not affect the HRI trust directly. Personal training would influence the group mental model, which includes culture and communication patterns. Since all the participants were from the same region, the training process would form the same personal behavior and culture and communication patterns. This reason also explained why seven out of ten law-enforcement officers thought about training with drones before the operation.

In this study, there were a few limitations. Seven out of ten participants mentioned the drone field of view is limited, which is 82.6 degrees. In comparison, average human eyes' binocular field view is 120 degrees with an additional 60 - 70 degrees accounting for peripheral vision (Sukhatme, 2011).

The drone had no ability to precisely locate itself, so participants would need to

remember the location and be forced to determine the position of the drone in the environment.

CHAPTER 5. CONCLUSION

This study assesses the impacts of single monitor swarm feeds' and multiple monitors swarm feeds' interface setting on target identification, operator mental load, and human-machine truth by using multiple drone swarm feeds in a regional law-enforcement building clearing operation. Twenty participants completed forty runs and identified targets correctly in thirty-five runs. Both single monitor single drone and single monitor swarm had a 10% error rate, and all were type I error. However, multiple monitors swarm had a 20% error rate, and one type II error occurred.

Adding additional drones reduced the amount of time, which law enforcement officer is exposed in a dangerous environment, in a clearing operation approach. Because of the safety reason, drone and drone swarm is the future of law-enforcement operations. Because drone or drone swarm can fly through those fatal funnels as I mentioned before. And, they will save the law enforcement officer life at an affordable cost. Although the optimal drone swarm interface is setting demand more mental workload, single monitor swarm setting provides a safe and stable approach with a smoother working pace.

Despite there were no complaints about cooperating with drones, and they were looking forward to working with drone or drone swarm, participants gave the considerations and comments towards the future work and drone design. They mentioned the inefficient communication in the trails due to the model of perceiving images, decoding the information, making decisions, and sending a command to the drone. The communication pattern did not fit the daily law-enforcement communication pattern, which was formed during the law-enforcement personal training. The technique issues also reduce the dependability and predictability because the limited camera angle provided less information, and the interface

cannot provide the map for the operator, which increases the complexity in operation. Despite those suggestions, 70% of participants were willing to train with drones, which have mature technology and working with them in the future.

CHAPTER 6. FUTURE WORK

There were few limitations mentioned in the discussion which can help us to build off in the future.

This study can be extended if the drone can fully be automated, searching the room and establishing the map which can be sent back to the operator. The drone can highlight the object in different colors and direct feedback to the operator, reducing the amount of law-enforcement officer cognitive decoding time. The drone's camera field view angle should be updated to human size, and a thermal camera can be used to identify the targets.

In the future study, a group of participants should train with drones and get familiar with human and drone interaction patterns before the clearing operation. The environment can be changed to an unfamiliar location, which is different from this case, where all participants knew the layout of the building before the study. This change would help researchers to have a better understanding of the environment as a critical factor in the trust of human-machine interaction.

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APPENDIX A. IRB APPOVAL

IOWA STATE UNIVERSITY
OF SCIENCE AND TECHNOLOGY

Institutional Review Board
Office for Responsible Research
Vice President for Research
2420 Lincoln Way, Suite 202
Ames, Iowa 50014
515 294-4566

Date: 2/23/2018

To: Thomas Michael Schnieders
3004 Black Engr

CC: Dr. Richard T Stone
3004 Black Engineering
Zhonglun Wang
616 Billy Sunday Rd.Unit 201

From: Office for Responsible Research

Title: The Effect of Human Robot Interaction on Trust, Situational Awareness, and Performance in Drone Sweeping

IRB ID: 18-016

Approval Date:	2/23/2018	**Date for Continuing Review:**	2/22/2020
Submission Type:	New	**Review Type:**	Expedited

The project referenced above has received approval from the Institutional Review Board (IRB) at Iowa State University according to the dates shown above. Please refer to the IRB ID number shown above in all correspondence regarding this study.

To ensure compliance with federal regulations (45 CFR 46 & 21 CFR 56), please be sure to:

- **Use only the approved study materials** in your research, **including the recruitment materials and informed consent documents that have the IRB approval stamp.**
- **Retain signed informed consent documents for 3 years after the close of the study,** when documented consent is required.
- **Obtain IRB approval prior to implementing any changes** to the study by submitting a Modification Form for Non-Exempt Research or Amendment for Personnel Changes form, as necessary.
- **Immediately inform the IRB of** (1) **all serious and/or unexpected adverse experiences** involving risks to subjects or others; and (2) **any other unanticipated problems involving risks** to subjects or others.
- **Stop all research activity if IRB approval lapses,** unless continuation is necessary to prevent harm to research participants. Research activity can resume once IRB approval is reestablished.
- **Complete a new continuing review form** at least three to four weeks prior to the **date for continuing review** as noted above to provide sufficient time for the IRB to review and approve continuation of the study. We will send a courtesy reminder as this date approaches.

Please be aware that IRB approval means that you have met the requirements of federal regulations and ISU policies governing human subjects research. **Approval from other entities may also be needed.** For example, access to data from private records (e.g. student, medical, or employment records, etc.) that are protected by FERPA, HIPAA, or other confidentiality policies requires permission from the holders of those records. Similarly, for research conducted in institutions other than ISU (e.g., schools, other colleges or universities, medical facilities, companies, etc.), investigators must obtain permission from the institution(s) as required by their policies. **IRB approval in no way implies or guarantees that permission from these other entities will be granted.**

Upon completion of the project, please submit a Project Closure Form to the Office for Responsible Research, 202 Kingland, to officially close the project.

Please don't hesitate to contact us if you have questions or concerns at 515-294-4566 or IRB@iastate.edu.

IRB ID: 18-016

INSTITUTIONAL REVIEW BOARD (IRB)
Application for Approval of Research Involving Humans

Title of Project: The Effect of Human Robot Interaction on Trust, Situational Awareness, and Performance in Drone Sweeping Operations

Principal Investigator (PI): Tom Schnieders			Degrees: MS IMSE, MS HCI, BS ME
University ID: 611573963	Phone: 845-492-0509	Email Address: tms@iastate.edu	
Correspondence Address: 0066 Black Engineering, Iowa State University, Ames, Iowa 50010			
Department: Industrial Engineering		College/Center/Institute: Engineering	

PI Level: ☐ Tenured, Tenure-Eligible, & NTER Faculty ☐ Adjunct/Affiliate Faculty ☐ Collaborator Faculty ☐ Emeritus Faculty
☐ Visiting Faculty/Scientist ☐ Senior Lecturer/Clinician ☐ Lecturer/Clinician, w/Ph.D. or DVM ☐ P&S Employee, P37 & above
☐ Extension to Families/Youth Specialist ☐ Field Specialist III ☐ Postdoctoral Associate ☒ Graduate/Undergrad Student ☐ Other (specify:)

FOR STUDENT PROJECTS *(Required when the principal investigator is a student)*		
Name of Major Professor/Supervising Faculty: Dr. Richard T Stone		
University ID: 103229126	Phone: 5152943644	Email Address: rstone@iastate.edu
Campus Address: 3027 Black Engineering		Department: Industrial Engineering
Type of Project (check all that apply): ☐ Thesis/Dissertation		☒ Class Project ☐ Other (specify:)

Alternate Contact Person: Zhonglun Wang	Email Address: zhonglun@iastate.edu
Correspondence Address: 0066 Black Engineering	Phone: 515-708-1931

IRB
JAN 12 2018

ASSURANCE

- I certify that the information provided in this application is complete and accurate and consistent with any proposal(s) submitted to external funding agencies. Misrepresentation of the research described in this or any other IRB application may constitute non-compliance with federal regulations and/or academic misconduct.
- I agree to provide proper surveillance of this project to ensure that the rights and welfare of the human subjects are protected. I will report any problems to the IRB. See Reporting Adverse Events and Unanticipated Problems for details.
- I agree that modifications to the approved project will not take place without prior review and approval by the IRB.
- I agree that the research will not take place without the receipt of permission from any cooperating institutions when applicable.
- I agree to obtain approval from other appropriate committees as needed for this project, such as the IACUC (if the research includes animals), the IBC (if the research involves biohazards), the Radiation Safety Committee (if the research involves x-rays or other radiation producing devices or procedures), etc., and to obtain background checks for staff when necessary.
- I understand that IRB approval of this project does not grant access to any facilities, materials, or data on which this research may depend. Such access must be granted by the unit with the relevant custodial authority.
- I agree that all activities will be performed in accordance with all applicable federal, state, local, and Iowa State University policies.

Thomas M. Schnieders 12 January 2018
Signature of Principal Investigator Date

R T Stone 1/12/18
Signature of Major Professor/Supervising Faculty Date
(Required when the principal investigator is a student)

- I have reviewed this application and determined that departmental requirements are met, the investigator(s) has/have adequate resources to conduct the research, and the research design is scientifically sound and has scientific merit.

FRANK PETERS ACTING CHAIR 1/12/18
Printed Name of Department Chair/Head/Director Signature of Department Chair/Head/Director Date

For IRB Use Only	Full Committee Review: ☐	Review Date: 2-23-2018
	EXPEDITED per 45 CFR 46.110(b): Category 6,7 Letter 1	Approval/Determination Date: 2-23-2018
Approval Not Required: ☐		Approval Expiration Date: 2-22-2020
Not Research: ☐	EXEMPT per 45 CFR 46.101(b):	
No Human Subjects: ☐	Not Approved: ☐	Risk: Minimal ☑ More than Minimal ☐
IRB Reviewer's Signature	Lisa A. Tabor 2-23-2018	

page replaces 2/6/18

Research Involving Humans Study Information

Please provide answers to all questions, except as specified. Incomplete forms will be returned without review.

PART A: KEY PERSONNEL

1. List all members and relevant qualifications of the project personnel and define their roles in the research. Key personnel include the principal investigator, co-principal investigators, supervising faculty member, and any other individuals who will have contact with the participants or the participants' data (e.g., interviewers, transcribers, coders, etc.). This information is intended to inform the committee of the training and background related to the specific procedures that each person will perform on the project. For more information, please see Human Subjects – Persons Required to Obtain IRB Training.

NAME	Interpersonal contact or communication with subjects, or access to private identifiable data?	Involved in the consent process?	Contact with human blood, specimens, or other biohazardous materials?	Other Roles in Research	Qualifications (i.e., special training, degrees, certifications, coursework, etc.)	Human Subjects Training Date
Thomas M. Schnieders	☒	☒	☐		BSME, MSHCI, MSIMSE	8/13/12 ✓
Richard T. Stone	☒	☒	☐		Dr. Stone has run several IRB approved studies at both ISU and UB	9/2/08 ✓
Zhonglun Wang	☒	☒	☐		NIH Training	5/17/13 ✓
Erik Danford-Klein	☒	☒	☐		NIH Training	4/12/16 ✓
Kevin Push	☒	☒	☐		NIH Training	1/11/18 ✓
Gary Mirka	☒	☒	☐		NIH Training	12/16/16 ✓
	☐	☐	☐			
	☐	☐	☐			
	☐	☐	☐			
	☐	☐	☐			
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	☐	☐	☐			
	☐	☐	☐			
	☐	☐	☐			
	☐	☐	☐			
	☐	☐	☐			
	☐	☐	☐			

Please complete additional pages of key personnel as necessary.

☐ Yes ☒ No	2.	**Does your study include children (persons under age 18) as research subjects?**
		If ***Yes***, please read and respond to the following: ISU policy requires that background checks be completed for all researchers and key personnel who will have any contact with children involved in this research project. Details regarding this policy can be found here. **Principal Investigators and faculty supervisors are responsible** for ensuring that background checks are completed BEFORE researchers or key personnel may have any contact with children. Records documenting completion of the background checks must be kept with other research records (e.g., signed informed consent documents, approved IRB applications, etc.) and may be requested during any audits or Post-Approval Monitoring of your study.
☒ Agreed	2.a.	**Please check here to indicate that you have read this information and agree that you will comply with these requirements.**

PART B: FUNDING INFORMATION AND CONFLICTS OF INTEREST

☐ Yes ☒ No	1.	**Is or will the project be externally funded?**
		If ***No***, skip to question 8.
		If ***Yes***, please identify the type(s) of source(s) from which the project is directly funded. ☐ Federal agency ☐ State/local government agency ☐ University or school ☐ Foundation ☐ Other non-profit institution ☐ For-profit business ☐ Other; specify:
☐ Yes ☐ No	2.	**Is ISU considered to be the Lead or Prime awardee for this project?**
☐ Yes ☐ No	3.	**Are there or will there be any subcontracts issued to others for this project?**
☐ Yes ☐ No	4.	**Is or will this project be funded by a subcontract issued by another entity?**
☐ Yes ☐ No	5.	**If ISU is the recipient of the subcontract, does it involve any federal funding, such as federal flow-through funds?**
6.		**If this project will be externally funded, please provide the complete name(s) of the funding source(s); please do not use acronyms.** If any subcontracts will be issued to others, please describe and include a list of all entities.

☐ Attached	7. **Please attach a complete and final copy of the entire grant proposal or contract from which the project is or will be funded.**
☐ Yes ☒ No	8. **Do or will any of the investigators or key personnel listed on this application have a conflict of interest management plan in place with the Office of the Vice President for Research & Economic Development?**

PART C: GENERAL OVERVIEW – PURPOSE AND EXPECTED BENEFITS

1. **Research Objectives** – Briefly explain in language *understandable to a layperson* the purpose and specific aim(s) of the study.
The purpose of this study is to investiage how a drone affects trust, situational awareness, and performacne in drone sweeping operations.
2. **Broader Impacts/Significance** – Explain in language *understandable to a layperson* why this research is important and how the information gained in this study is expected to advance knowledge and/or serve the good of society.
The importance of this research is to understand if robots help the team performance of the task and how people interact while using a robot.

☐ Yes ☒ No	3. **Benefits to Participants** – Are there any expected direct benefits to research participants from participation in the research? **Note:** Monetary compensation is ***not*** considered to be a benefit of participation in research.
	If ***Yes***, please describe the expected benefits to participants.

PART D: PARTICIPANT SELECTION

1. **How many individuals do you plan to include in the study (including those involved in screening procedures)?** The number listed here is the **maximum number** of participants that may be included in the study.
200
2. **Inclusion Criteria** – Describe the specific characteristics of persons that will be included in your study, **and provide justification for these requirements.**

Law enforcement personnel above the age of 18 who can legally give consent and do not have conditions which would inhibt a sweeping operation of a 2-3 story building are invited to participate in this research study.

3. Exclusion Criteria – Describe the characteristics of persons who will not be allowed to participate in your study, **and provide justification for their exclusion.**

Participants who have conditions which would prohibit walking over uneven terrain or up and down stairs for two hours.

4. Do you intend, or is it likely, that your study will include any persons from the following vulnerable populations? (Check all that apply.)

- ☐ Children (any persons under age 18, including ISU/college students who may be under age 18)
  Specify age range:
- ☐ Prisoners
- ☐ Persons with impaired decision-making capacity, such as those with dementia or severe cognitive impairment, those declared incompetent, persons in life-threatening situations, etc.
- ☐ Wards of the State
- ☐ Persons who are institutionalized
- ☐ Pregnant women or fetuses
- ☐ Neonates
- ☐ Educationally disadvantaged
- ☐ Economically disadvantaged
- ☐ Students in a class taught by the researchers
- ☐ Employees or subordinates of the researchers
- ☐ Other vulnerable population, given the setting of your research; please describe:

☐ **Yes** ☒ **No** **5. Will ISU students or other college students be asked to participate in your study?**

☐ **Yes** see 5.a.(2) ☒ **No** see 5.a.(1) **5.a.** If ***Yes***, do you plan to ***include*** college students who may be under age 18?

5.a.(1) If ***No*** *(i.e., students under 18 will be **excluded** from your study)*, please describe how you will ensure college students under 18 do not participate in the study.

All participants IDs will be checked. If the person is under the age of 18, they will be asked to leave and will not be included in the study.

5.a.(2) If ***Yes*** *(i.e., students under 18 will be **included** in your study)*, please be sure to describe the parental consent and minor assent processes in Appendix E.

PART E: RECRUITMENT PROCEDURES

1. How will you identify or search for potential participants? (Check all that apply.)

- ☐ Review of public records (e.g., voter lists, utilities lists, phone directory, ISU directory, etc.)
- ☐ Review of private records (e.g., medical records, student records, other private records)
- ☐ Purchased mailing lists
- ☒ Personal contacts/knowledge

☐ "Snowball" sampling
☐ Participant responses to posted advertisements (electronic or hardcopy) or flyers
☐ Other; please describe:

2. Please describe the details of how each of the methods checked in #1 above will be implemented.

Personal contacts of the research team who are law enforcement personnel will be verbally asked to take part in the research study.

See addendum Item 1 for more details (OS)

3. What methods will you use to contact potential participants? (Check all that apply.)

☐ Letter or email
☐ Phone call
☐ Posting flyers
☐ Posting announcement on website (Check all that apply.)
  ☐ ISU Department of Psychology SONA system
  ☐ ISU Department of Marketing/MIS SONA system
  ☐ ISU Office of the Vice President for Research and Economic Development
  ☐ ISU Departmental/Research Project websites
  ☐ Other; please describe:
☐ Distribution of email or advertisement via Listserves or online bulletin-boards
☐ Television or radio advertisements
☐ Personal or verbal announcement, such as in a class, meeting, etc.
☒ Informal, personal communication
☐ Other; please describe:

4. Please describe the details of how each of the methods checked in #3 above will be implemented.

Prospective participants will be verbally asked to participate following the attached Informal Announcement document. The prospective participants will be able to send emails to the research team whether they have questions or they want to participate.

☒ **Yes** ☐ **No** **5. Attached are copies of any letters, emails, phone/verbal scripts, flyers, announcements, or advertisements that will be used. Please know the IRB must review final and complete copies of all materials used to contact or recruit subjects. For verbal processes, a script or list of points to be covered during the discussion must be provided.**

If ***No***, please explain why:

PART F: SCREENING PROCEDURES

☐ **Yes** ☒ **No** **1. Will participants be asked to provide any information about themselves (e.g., medical history, personal characteristics) for screening purposes prior to enrollment in the study?**

If ***Yes***, please describe:

☐ Yes ☒ No	**2. Will participants be asked to take part in any interventions (e.g., fasting, blood draws, etc.) for screening purposes prior to enrollment in the study?**
	If *Yes*, please describe:
3. If *Yes* to question 1 and/or 2, please describe how you will obtain the informed consent of participants PRIOR to their participation in screening activities.	

PART G: COMPENSATION

☐ Yes ☒ No	**1. Will participants receive any of the following types of compensation for their participation in your research? (Check all that apply.)** ☐ Money (cash or check) ☐ Gift cards ☐ Gifts ☐ Reimbursement for expenses (i.e., costs of travel to lab, child care, meals, etc.) ☐ Course credit (including extra credit) ☐ Other; specify:
	2. If ***Yes***, please answer questions 2a through 2d. ***This information should also be provided in the informed consent document.***
	2.a. Describe the specific amount of compensation to be provided (i.e., in monetary terms, points for course credit, value of gifts, etc.).
	2.b. Explain how compensation will be provided if the participant withdraws prior to completion of the study. **Note:** Completion of all study procedures cannot be a requirement for research participants to receive compensation.
	2.c. If course credit is given, describe alternative ways students can earn the same amount of credit and how these alternatives are *genuinely comparable* to participation in the study in terms of time and effort.

2.d. If the study involves multiple visits, sessions, or time-points, how will compensation be prorated (e.g., how much will be provided per visit/session/time-point)?
Note: Compensation plans must be in accordance with policies set forth by the ISU Controller's Department. Detailed information is available here.

PART H: RESEARCH PLAN

1. Research Procedures – Using *layperson's terminology*, please describe in detail your plans for collecting data from participants. Include a description of **all** *procedures, tasks, or interventions* participants will be asked to complete during the research (e.g., random assignment, any conditions or treatment groups into which participants will be divided, mail survey or interview procedures, observation protocols, sensors to be worn, amount of blood drawn, etc.).

Note: When referencing attached documents (i.e., surveys, interview protocols, copies of stimuli, instructions for tasks, etc.), please ensure that each attachment is clearly labeled and clearly referenced in this section.

Participants will meet at the study location. This will be a 2-3 story building. The participants will be given an overview of the study and the informed consent (Attachment B: Informed Consent Form) to sign. Each participant will fill out a pre-experiment survey (Attachment C: Pre-Experiment Survey). The participants will randomly be put into one of three groups (control, experimental group 1, and experimental group 2). Experimental groups 1 and 2 will be given a quadcopter to use during the task. The quadcopter will be able fly and will have a video camera attached to relay information to the team. This team will be provided a trained drone operator. This task will involve navigating the environment. Team communication may be recorded, location tracking may be applied.* One or more people on the team will be asked to wear pedometers to track the amount of steps taken. When the group starts they will be observed by the research team. At the end of the experiment the participants will be asked to complete a short survey (Attachment D: Post-Experiment Survey). Participants will be debriefed (Attachment F: Debriefing).

See addendum for additional details (DB) items 2–5

* per email 2/21/18 - location tracking is only through notes, pedometer + communication (DB)

RESEARCH INVOLVING DECEPTION OR INCOMPLETE DISCLOSURE

☐ Yes	☒ No	**2. Will participants be *deceived or misled* about anything during the study?** If ***Yes***, please answer questions 2a through 2d in Appendix A. If ***No***, please skip to question 3.
☐ Yes	☒ No	**3. Do you plan to *intentionally withhold* information from participants, such as the full purpose of the study, a full description of procedures, etc.?** If ***Yes***, please answer questions 3a through 3d in Appendix A. If ***No***, please skip to question 4.

RESEARCH INVOLVING EXISTING DATA OR INFORMATION FROM RECORDS

☐ Yes ☒ No

4. **Does the research involve the collection or study of currently existing data or information to be gathered from records, such as the following? (Check all that apply.)**
   - ☐ Student/educational records (including collection of class assignments, tests, etc.)
   - ☐ Medical records (If checked, submit the Application for Use of Protected Health Information.)
   - ☐ Data collected for a previously conducted study
   - ☐ Information from government databases, such as the US Census, Iowa Dept. of Public Health records, etc.
   - ☐ Samples from specimen/tissue banks
   - ☐ Other; please describe:

   If ***Yes***, please answer questions 4a through 4g in **Appendix B**.
   If ***No***, please skip to question 5.

RESEARCH INVOLVING OBSERVATION

☒ Yes ☐ No

5. **Does the research involve collection of data from observation of people's behaviors or activities?**
   If ***Yes***, please answer 5a through 5d in **Appendix C**.
   If ***No***, please skip to question 6.

RESEARCH INVOLVING INTERNATIONAL RESEARCH

☐ Yes ☒ No

6. **Will the research take place in an international setting?**
   If ***Yes***, please answer 6a through 6c in **Appendix D**.
   If ***No***, please skip to question 7.

RESEARCH INVOLVING INVESTIGATIONAL DRUGS, DEVICES, DEXA/CT SCANS, X-RAYS, OR HUMAN CELLS OR TISSUES

☐ Yes ☒ No

7. **Does this project involve an investigational new drug (IND)?** Number:

☐ Yes ☒ No

8. **Does this project involve an investigational device exemption (IDE)?** Number:

☐ Yes ☒ No

9. **Does this project involve DEXA/CT scans or X-rays?**

☐ Yes ☒ No

10. **Does this project involve human blood components, body fluids, or tissues?**

☐ Yes ☒ No

11. **Does this project involve human cell or tissue cultures (primary or immortalized)?**

If you answered *Yes* to either question 10 or 11 and the cells, body fluids, etc., have not been documented to be free of blood-borne pathogens, personnel handling these substances are required to take Blood-borne Pathogens Training annually.

Bloodborne Pathogens training is online via the EH&S website.

If you have any questions, contact EH&S at (515) 294-5359.

PART I: DATA ANALYSIS

1. Describe how the data will be analyzed (*e.g., statistical methodology, statistical evaluation, statistical measures used to evaluate results*).
The approach to analysis will use qualitative analysis techniques (e.g., thematic analysis, cognitive task analysis). The qualitative team communication will be analyzed using such as thematic analysis. The data will be analyzed using statistical methods such as a chi-square analysis, t-test, and ANOVA to understand the relationships among the scaled measures and any relationships between the demographic data and the scaled measures.

PART J: CONSENT PROCESS

According to federal regulations, participants can only be included in research if they, or their legally authorized representative, provide legally-effective informed consent. In some cases, the IRB can waive this requirement.

I. Consent for Adult Participants

☒ **Yes** ☐ **No**	**A. Will you obtain the informed consent of all participants?**
If **A** is ***Yes***, please answer the following questions:	
	1. Describe the procedures you will use to provide information about the details of the study to participants.
	The participants will review the informed consent document and be able to ask any questions related to the study before signing the document.
	2. Who, in general, will obtain informed consent from participants (i.e., explain the study, collect signed forms, etc.)? Please do not list actual names of study staff; rather, describe their role such as "the principal investigator," "research assistants," etc.
	PI and Co-PIs will all distribute and collect the consent forms.
	2.a. What training have they received or will they receive regarding how to appropriately obtain informed consent?
	The research team have all completed the NIH training.
	3. Information conveyed to participants must be in a language understandable to them. Please describe the measures you are taking to ensure the informed consent process

	is understandable (e.g., translation into another language, using commonly understood terminology, assessing reading level of the consent form, etc.).
	The informed consent will be in easily understood language. If there are any questions, the PI/Co-PI will explain what it means.
	3.a. If translation is required, please provide the name of the person(s) who conducted the translation(s) and his/her qualifications for doing so.
	4. When will informed consent be obtained in relation to beginning data collection?
	Informed consent will be collected at the beginning of the study.
☒ **Yes** ☐ **No**	**5. Will all participants sign a consent form to document the consent process? Note:** Signatures must be handwritten by the participant; typing one's name on a form does not constitute a legally valid signature according to federal regulations. If ***No***, please explain why.
☐ **Yes** ☒ **No**	**6. Do any of the researchers or key personnel involved in the study have a supervisory, evaluative, or other position of "power" over participants?** If ***Yes***, please describe the measures you are taking to minimize any coercion or undue influence (real or perceived).
☐ **Yes** ☒ **No**	**7. Are any participants likely to be unable to provide consent for themselves, such as those who have severe cognitive impairments, dementia, are in life-threatening situations, cannot communicate, etc.?** If ***Yes***, please describe plans to obtain consent from the participant's legally authorized representative.
	7.a. To the extent possible, given the condition of the participant, how will you ensure they agree to take part in the research?
If **A** is ***No***, (i.e., you will NOT obtain informed consent from all participants), please answer the following:	
	8. Please provide strong and compelling justification for why you cannot carry out your study if you had to obtain informed consent. Note: The fact that obtaining consent would be inconvenient or time consuming is **not** considered to be sufficient justification.

	9. Please explain why participants' rights and welfare will not be adversely affected if you do not obtain their consent.

II. Parent/Legal Guardian Consent and Child Assent (applies when participants are under age 18 or are considered to be children in the country where the research takes place)

☐ Yes ☒ No	**A. Does your study involve children?**
If **A** is ***Yes***, please complete the questions in **Appendix E**.	

PART K: RISKS/DISCOMFORTS

☐ Yes ☒ No* see 1.a.-1.g.	**1. Are there any foreseeable risks or discomforts to participants from taking part in your research?** *If ***No***, please answer the following question.
	If ***No (i.e., there are no foreseeable risks or discomforts to participants)***, please explain why you believe this is the case:
	There is no expected risks or discomforts to the participants that is not expected in the participants regular operations. Participating in the research study does not in any way increase risk.
	* See addendum about risk + procedures (60)
	If ***Yes***, please answer ***Yes*** or ***No*** to items **1.a through 1.g** below. Indicate whether the following types of risks/discomforts are foreseeable. When ***Yes***, please describe the risks/discomforts **and** explain how each will be mitigated or minimized.
☐ Yes ☒ No	**1.a.** Physical Risks (e.g., injury, bruising from a blood draw, pain, side-effects from drugs administered, allergic reactions, etc.)
☐ Yes ☒ No	**1.b.** Psychological Risks (e.g., emotional discomfort from answering questions, stress or anxiety from procedures, mood alterations, viewing offensive or "shocking" materials, etc.)
☐ Yes ☒ No	**1.c.** Social Risks (e.g., harm to reputation, embarrassment, or stigmatization if participation becomes known, disruption of personal or family relationships, etc.)

☐ Yes ☒ No	**1.d.** Economic Risks (e.g., loss of money, loss of or harm to employment, etc.)
☐ Yes ☒ No	**1.e.** Legal Risks (e.g., criminal liability if information about participants' illegal behaviors is collected)
☐ Yes ☒ No	**1.f.** Informational Risks (e.g., harm if information collected about the participant were disclosed or overheard, such as embarrassment, retribution, stigmatization, disruption of personal relationships, legal liability, etc.)
☐ Yes ☒ No	**1.g.** Other Risks, given the setting of your research

PART L: PRIVACY AND CONFIDENTIALITY

1. Describe how participants' privacy will be protected during recruitment and data collection (e.g., discussions/procedures will be conducted in private locations, messages regarding the research will not be left on answering machines without permission of participant, documents or recordings will be kept secure, etc.).	
Each participant will be randomly assigned a number. Their data will be recorded only in terms of that number and team name. A key linking the number to each participant will be recorded onto a hard copy list and will be kept in the locked office of Dr. Stone. See addendum for more details about audio recordings + note taking.	
2. Please answer the following questions to describe the methods you will employ to maintain confidentiality and security of the data at all points in the research process (e.g., during data collection, during analysis, etc.):	
	2.a. Who will have access to the data and study records?
	PI and Co-PIs who are listed in Part A: Key Personnel section.
	2.b. Describe how/where physical copies (i.e., paper files, samples, etc.) of data and study records will be stored (e.g., in cabinets, desks, shelves, etc.).
	Physical copies of data will be stored in a locked cabinet at 0066 Black Engineering.
	2.c. Describe security measures in place to maintain security of physical/paper data, samples, or study records (e.g., how access will be controlled, locks, etc.).
	Hard copies will be kept at locked cabinet in 0066 Black Engineering.

	2.d. Describe how/where electronic data will be stored (e.g., a desktop computer, laptop, portable drive, shared drive, etc.).
	Electronic data will be kept with password-protected folders at shared drive. - on Cybox per email 1/29/18 DA
	2.e. Describe the measures in place to maintain security of electronic data (e.g., encryption, password-protection, firewalls, using university controlled systems, etc.).
	Password protection.
☒ Yes ☐ No	**2.f.** Will your data include any audio recordings and/or video recordings of participants? If ***Yes***, please answer the following:
	2.f.(1) Who will have access to the audio and/or video recordings?
	PI and Co-PIs
	2.f.(2) Describe how/where the audio and/or video recordings will be stored (e.g., in a cabinet, on a computer, etc.).
	Recorded data will be kept on Cybox which is password-protected folders at University drive.
	2.f.(3) Describe the measures in place to maintain security and confidentiality of the audio and/or video recordings (e.g., how access will be controlled, locks, password protection, firewalls, etc.).
	Password protection. Only PI and Co-PIs will have access.
☒ Yes ☐ No	**2.f.(4)** Will the actual recordings or images of participants from recordings be shared in any dissemination (e.g., manuscripts, reports, presentations, etc.) of the study results? If ***Yes***, what measures will you take to disguise their identity (i.e., blurring facial images, voice alteration methods, etc.)?
	Password protection. Only PI and Co-PIs will have access.
☐ Yes ☒ No	**2.g.** Will any identifiers or identifiable information (e.g., names, social security numbers, addresses, phone numbers, exact dates of birth, etc.) be collected with or linked to the study data at **any point in time**? If ***Yes***, please answer the following:
	2.g.(1) Describe the identifiers that will be collected or linked to the study data.
	2.g.(2) Why is it necessary to collect identifiers or link identifiers to the study data?

2.g.(3) At what point in the process will identifiers be separated or removed from the data?

2.g.(4) Please describe any coding systems you will use to maintain confidentiality of identifiable data (e.g., plans to replace names with ID codes or pseudonyms).

☒ **Yes** ☐ **No** **2.g.(5)** Will you create a "key" linking identifiers with any ID codes or pseudonyms?

If ***Yes***, how will you maintain control of the key and ensure the key is kept secure? **Note:** Best practice is to store the key in a separate location from the study data.

The key linking each participant to an ID number will be kept in locked cabinets in Dr. Stone's office.

At what point will the key be destroyed?

Three years after the end of the project.

☐ **Yes** ☒ **No** **2.h.** Have you or will you obtain a Federal Certificate of Confidentiality for this study? If ***Yes***, please submit a copy of the certificate materials with this application. **Note:** Certificates of Confidentiality are designed to protect identifiable research records against forced disclosure (e.g., subpoena). Certificates can be sought from the National Institutes of Health in certain circumstances. Visit the **Certificates of Confidentiality Kiosk for more information.**

☐ **Yes** ☒ **No** **2.i.** Will the data be shared or submitted to a repository or registry, such as the Clinical Trial Registry Databank (ClinicalTrials.gov), the Database of Genotypes or Phenotypes, or via other data sharing agreements? If ***Yes***, please describe.

3. What specific steps will you take to ensure participants are not identifiable (directly or indirectly via "deductive disclosure") when research results are reported?

Names will only appear on the consent forms, which will be separated from all other data. All data will be identified with a unique ID number. All results will be reported in aggregate. If any quotes or individual data is presented, it will be only identified with ID number.

☒ **Yes** **4.** Please check here to confirm that you will retain research records (i.e., signed consent forms, approved IRB applications, etc.) for at least 3 years after the study is complete. Doing so is required by federal regulations.

PART M: REGISTRY PROJECTS

☐ Yes ☒ No	**1. Does this project establish a registry or databank?** **Note:** To be considered a registry or databank: (1) the individuals whose data are in the registry/databank might be contacted in the future; and/or (2) the names and/or data pertaining to the individuals in the registry/databank might be used by investigators other than the one maintaining the registry/databank.
	If ***Yes***, please answer the following questions:
	1.a. What information/data will be included in the registry?
	1.b. What is the reason for establishing a registry (i.e., how will data from the registry be used)?
	1.c. Who will be involved in establishing and providing oversight of the registry?
☐ Yes ☐ No	**1.d.** Will the data in the registry be available to anyone other than the investigator(s) who maintain the registry?

Checklist for Attachments

Listed below are the types of documents that should be submitted for IRB review. Please check **and attach** the documents that are applicable for your study:

- ☐ Grant proposal or contract—must be the complete and final version submitted to funding agency
- ☐ Recruitment fliers, phone scripts, or any other documents or materials participants will see or hear
- ☐ A copy of the informed consent document or letter of introduction containing the elements of consent
- ☐ A copy of the assent form if minors will be enrolled
- ☐ Data-gathering instruments (including surveys, interview questions, focus group protocols, cognitive tests, observation protocols, etc.)
- ☐ When applicable, copies or detailed descriptions of stimuli participants will be exposed to, instructions for testing, investigator's brochures, etc.
- ☐ Appendices attached when applicable
  - ☐ Appendix A
  - ☐ Appendix B
  - ☒ Appendix C
  - ☐ Appendix D
  - ☐ Appendix E

The original signed copy of the application form, any completed appendices, and one set of accompanying materials should be submitted for review in hard copy to the Office for Responsible Research, 1138 Pearson, or electronically to IRB@iastate.edu.

APPENDIX

The sections in this appendix are color-coded to correspond with the colored sections in the main application. Please complete the items in the appendix only if directed to do so in the main application. Please ensure all questions in the main application and any necessary appendices have been addressed before sending to the IRB for review.

A. RESEARCH INVOLVING DECEPTION OR INCOMPLETE DISCLOSURE

Continuation from Part H: #2:
2.a. Please explain in detail how persons will be deceived or misled.
2.b. Please provide strong and compelling justification for why it is scientifically necessary to deceive or mislead participants in order to conduct the research and why a non-deceptive methodology is not possible.
2.c. Please explain the steps you will take to ensure participants' rights and welfare are not adversely affected by deceiving or misleading them.
2.d. Please describe the process you will use to "debrief" participants and explain the ways they were deceived or misled during the study. A copy of the information to be provided during debriefing must be attached.
Continuation from Part H: #3:
3.a. Please explain in detail what information will be withheld.
3.b. Please provide strong and compelling justification for why it is scientifically necessary to intentionally withhold information from participants in order to conduct the research.
3.c. Please explain the steps you will take to ensure participants' rights and welfare are not adversely affected by withholding information from them.

3.d. Please describe the process you will use to "debrief" participants and explain the information that was withheld. A copy of the information to be provided during debriefing must be attached.

Continue to Part H: #4 (Existing Data)

B. RESEARCH INVOLVING EXISTING DATA OR INFORMATION FROM RECORDS

Continuation from Part H: #4:

4.a. What is/are the source(s) of the data/records?

☐ **Yes** ☐ **No** **4.b.** Are *all of* the data/records **publicly** available, without restriction?

4.c. Describe the specific variables, information, or content that will be obtained from the data/records.

☐ **Yes** ☐ **No** **4.d.** Is the use of the data/records subject to any restrictions, such as the following? (Check all that apply.)

- ☐ FERPA—The Family Educational Rights and Privacy Act (applies to student records)
- ☐ HIPAA—The Health Insurance Portability and Accountability Act (applies to medical records) – *If checked, submit the Application for Use of Protected Health Information.*
- ☐ Institutional policies (for personnel records or other private records)
- ☐ Confidentiality provisions promised to the persons whose data you will obtain, such as those described in previously signed informed consent documents
- ☐ Other; please describe:

4.d.(1) If ***Yes***, please describe how you will meet or address those restrictions when obtaining the data.

☐ **Yes** ☐ **No** **4.e.** Will any of the following identifiers be included with the information you obtain from these records? (Check all that apply.)

- ☐ Names: ☐ First Name Only ☐ Last Name Only ☐ First and Last Name
- ☐ Phone/fax numbers
- ☐ ID codes that can be linked to the identity of the participant (e.g., student IDs, medical record numbers, account numbers, study-specific codes, etc.)
- ☐ Addresses (email or physical)
- ☐ Social security numbers
- ☐ Exact dates of birth
- ☐ IP addresses
- ☐ Photographs or video recordings
- ☐ Other; please specify:

☐ **Yes** ☐ **No** **4.f.** Is there a reasonable possibility that participants' identities could be ascertained from any combination of information in the data? If ***Yes***, please describe:

☐ Yes ☐ No	**4.g.** Will you obtain the permission/consent of the persons to whom the data/records pertain to use their information in your research?
	4.g.(1) If ***Yes***, please describe this process.
	4.g.(2) If ***No***, please provide **strong** justification for why obtaining permission/consent is not necessary or not possible. **Note**: The fact that obtaining consent would be inconvenient or time consuming is **not** considered to be sufficient justification.
☐ **Attached**	**4.g.(3)** If access to the data/records is subject to any restrictions, please attach documentation from the record holder indicating that you may have access to the data/records without the written consent of the participant.

Continue to Part H: #5 (Observation)

C. RESEARCH INVOLVING OBSERVATION

Continuation from Part H: #5:	
	5.a. Please describe the specific behaviors or activities that will be observed.
	The plan that the team comes up with, where they walk, how they communicate, how much they communicate, their ability to fly the quadcopter, do they use the quadcopter the whole time, etc. See addendum for details on audio + note taking (6)
	5.b. How will you record information during observation (e.g., field notes, audio/video, etc.)?
	Field notes, audio recording.
☒ **Yes** ☐ **No**	**5.c.** Will any identifying information about participants be recorded during the observations? If ***Yes***, please describe:
	Yes. The communication will be recorded as audio. The audio recordings will be kept on Cybox, and only PI and Co-PIs have access.
☒ **Yes** ☐ **No**	**5.d.** Will participants give informed consent to be observed? If ***No,*** please provide **strong** justification for why obtaining permission/consent is not necessary or not possible. **Note**: The fact that obtaining consent would be inconvenient or time consuming is **not** considered to be sufficient justification.

Continue to Part H: #6 (International Research)

D. RESEARCH INVOLVING INTERNATIONAL RESEARCH

Continuation from Part H: #6:
6.a. Please describe the experience, knowledge, or other qualifications the investigators have related to conducting the research in this international setting(s).
6.b. Please describe the specific steps you are taking to ensure the research is conducted in accordance with the local norms and customs, cultural expectations, language needs, etc., in the international setting(s).
6.c. Please describe the specific steps you are taking to ensure the research is conducted in accordance with any policies, laws, or governmental requirements in each country where the research will take place.

Continue to Part H: #7 (Investigational Drugs, Devices, Etc.)

E. CONSENT PROCESS FOR CHILDREN INVOLVED IN RESEARCH

Continuation from Part J.II: #2:

Parent/Legal Guardian Consent and Child Assent (applies when participants are under age 18 or are considered to be children in the country where the research takes place)

According to federal regulations, children can only be enrolled in research if their parent(s) or legal guardian(s) have given consent, unless the IRB waives this requirement. Children must also agree to participate in the research to the extent such agreement is possible, given the child's age, communication abilities, etc.

☐ Yes ☐ No	**B. Will you obtain the informed consent of the parent/legal guardian for all children included in the study?**
If **B** is *Yes*, please answer the following questions:	
	1. Describe the process you will use to inform parents or legal guardians about the child's participation in the study (i.e., how you will make contact with parents/guardians, what will be shared with them, etc.).
	2. Who, in general, will obtain informed consent from parents/legal guardians (i.e., explain the study, collect signed forms, etc.)? Please do not list actual names of study staff; rather, describe their role such as "the principal investigator," "research assistants," etc.
	2.a. What training have they received or will they receive regarding how to appropriately obtain informed consent?
	3. Information given to parents/legal guardians must be in a language understandable to them. Please describe the measures you are taking to ensure the information is understandable (e.g., translation into another language, using commonly understood terminology, assessing reading level of the consent form, etc.).
	3.a. If translation is required, please provide the name of the person(s) who conducted the translation(s) and his/her qualifications for doing so.
	4. When will parental consent be obtained in relation to beginning data collection with children?

	5. How will you ensure that all children have the consent of their parent/legal guardian before including them in the study?
☐ **Yes** ☐ **No**	**6. Will a parent sign a consent form to document the consent process? Note:** Signatures must be handwritten by the parent; typing one's name on a form does not constitute a legally valid signature according to federal regulations.
	If ***No***, please explain why.
If **B** is ***No***, (i.e., you will NOT obtain informed consent from all parents/legal guardians), please answer the following:	
	7. Please provide strong and compelling justification for why you cannot carry out your study if you had to obtain parent/guardian consent. Note: The fact that obtaining consent would be inconvenient or time consuming is **not** considered to be sufficient justification.
	8. Please explain why participants' rights and welfare will not be adversely affected if you do not obtain parent/guardian consent.

The goal of the assent process is to ensure children are informed about the study and freely agree to take part. The process for obtaining assent from children must be appropriate for the age and development of the children involved in the study; in some cases, true assent may not be possible (such as with infants). Documentation of assent may not be appropriate for children who cannot read or write. Additionally, multiple assent processes may be necessary to ensure both younger and older children are adequately informed.

☐ **Yes** ☐ **No**	**C. Will you obtain assent for all children included in the study?** If ***Yes***, please answer the following questions:
If **C** is ***Yes***, please answer the following questions:	
	1. Describe the process you will follow to obtain the assent (i.e., "affirmative agreement") of each child.
	2. Who, in general, will obtain assent from each child (i.e., explain the study, collect signed forms, etc.)? Please do not list actual names of study staff; rather, describe their role such as "the principal investigator," "research assistants," etc.

2.a. What training have they received or will they receive regarding how to appropriately obtain assent, given the age range and developmental status of the children?
3. What steps are you taking to ensure information about the study is presented to each child in a language understandable to them (e.g., translation, simplified language, assessing reading level of any assent document, etc.)?
4. When will assent be obtained in relation to beginning data collection?
5. How will you know that each child has given assent (i.e., agreed to take part in the study)? (Check all that apply.) ☐ **Each child will sign an assent document following a verbal overview of the study (*applicable for children who can read and understand an assent document*).** ☐ **Each child will verbally indicate their agreement to participate (*applicable for children too young to read, who cannot read, or where a verbal process is most appropriate, given the age and ability of the children*).** ☐ **Other indication of assent (Please describe.)**
If **C** is ***No***, (i.e., you will NOT obtain assent from all children), please answer the following:
6. Please provide strong and compelling justification for why you cannot carry out your study if you had to obtain each child's assent. Note: The fact that obtaining assent would be inconvenient or time consuming is **not** considered to be sufficient justification.
7. Please explain why the child's rights and welfare will not be adversely affected if you do not obtain their assent.

Continue to Part K (Risks)

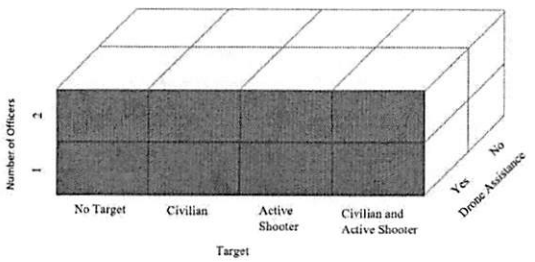
18-016 Review Addendum

Clarifications of this study in relation to required training vs participating in this research study from PI via phone conversation on 2/21/18:

1. Each prospective participant has training requirements for their employment. The study will be an auxiliary training advertised as an option to meet this requirement. Trainings of this nature already occur bi-monthly outside of the research study. Therefore participating in this particular training is option. Additionally, individuals who show up to this auxiliary training opportunity are able to participate in the training aspect of the event without needing to be a research participant. This training will count towards the Story County Sheriff's Office mandatory active shooter scenario training but participating in the research study is not required

Part H Clarifications Per email 1/29/18:

2. Description of a Sweeping Operation: A sweeping operation is also commonly referred to as a room clearing operation. It is a sequence of tasks that a tactical group performs to enter a potentially dangerous room while looking for any possible threats. The team members enter the room in sequence while checking every corner of the space they are clearing to ensure the room is safe or clear.
3. Drone Information: A YUNEEC Q500 drone will be used in the experiment. There are no restrictions on flying a drone indoors. The quadcopter will solely be flown by Dr. Stone, a trained drone operator.
4. The experiment is structured as a 2x4x2 factorial design. The differences can be seen in experimental design matrix below. The control group will consist of either one or two police officer(s) without drone assistance. They will perform the sweeping operation the same as the experimental group but without any drone feedback.



Audio Recording and Note Taking Clarifications- Per Email 2/06/18:

5. The research team will record the audio with a either a tape recorder or a built in voice memo application on a phone. Audio will be recorded when each group begins their sweeping operation and conclude after the informal interview. Audio communication between officer(s) and drone operator will be recorded by the research team. In addition, the research team may take notes of the operation as it proceeds. Audio recordings and field notes will be stored on an encrypted drive. Only the research team will have access to the encrypted drive. Specifics about the audio or who any identifying information will not be shared. Generalization of communications by all participants may be used for research purposes (i.e. 97% of participants developed a certain entry point plan, etc.). There is no plan to transcribe the audio.

ISU IRB # 1	18-016
Approved Date:	23 February 2018
Expiration Date:	22 February 2020

Informal Announcement

The Effect of Human Robot Interaction on Trust, Situational Awareness, and Performance in Drone Sweeping Operations

Hello all,

My name is [announcer name]. I am a [graduate] student at Industrial Engineering department, Iowa State University. Our team is conducting this study with Dr. Richard T. Stone. We invite you to be a volunteer for our study. During our experiment, you will be asked to complete given tasks with a team that requires using drone to assist with building clearing task. Your participation in this study is confidential.

This training is completely optional but will count towards Story County Sheriff's Office mandatory active shooter scenario training.

If you have any questions regarding to the study, please feel free to contact us at:
<Announcer will provide PI's email address and name for the PI and co-PI.>

ISU IRB # 1	18-016
Approved Date:	23 February 2018
Expiration Date:	22 February 2020

Informed Consent

The Effect of Human Robot Interaction on Trust, Situational Awareness, and Performance in Drone Sweeping Operations

This document describes a research project. It has information to help you decide whether you wish to participate. Research studies include only people who choose to take part – your participation is completely voluntary. Please discuss any questions you have about the study or about this form with the project staff before deciding to participate

Introduction

The purpose of this study is to investigate how a drone affects trust, situational awareness, and performance in drone sweeping operations.

This training is completely optional but will count towards Story County Sheriff's Office mandatory active shooter scenario training. Participants may choose to complete the active shooter scenario training and opt out of having their data collected for this study.

Inclusion Criteria

Law enforcement personnel above the age of 18 who can legally give consent and do not have conditions which would inhibit a sweeping operation of a 2-3 story building are invited to participate in this research study.

Description of Procedures

The procedure of this study is as follows:

1) Introductory briefing about the study
    a. Review informed consent form
    b. Explain the experiment
    c. Complete pre-experiment survey
2) If you agree to participate, you will perform the tasks in a 2-3 story building. You may be put on a team with other participants. Some teams will be given a quadcopter to assist in the sweeping operation task. The quadcopter will be able to fly and will have a video camera attachment to relay the aerial information to the team. Participants will not be flying the quadcopter. A trained quadcopter operator will be remotely piloting the quadcopter. One or more team members will be asked to wear pedometers to track the number of steps taken. Audio communication between officer(s) and drone operator will be recorded by the research team. In addition, the research team may take notes of the operation as it proceeds.

A principle investigator will explain how to perform a sweeping operation of a 2-3 story building. This task will involve tactical movement through a 2-3 story building where participants will attempt to identify a target. The target may or not be present. In the event that the target is present, the target will be a member of the research team and will be hidden somewhere within the building.

a. Group 1
    i. If you are assigned to this group, you will be placed in a team of two. You and your team member will perform the sweeping operation to identify and locate the target.
b. Group 2
    i. If you are assigned to this group, you will be placed in a team of two with a third team member who will be operating a quadcopter. You and your team member will perform the sweeping operation to identify and locate the target. The quadcopter operator will be providing information remotely to your team during the sweeping operation. The drone will be used to enter each room to be swept before the team.
c. Group 3
    i. If you are assigned to this group, you will not have a second on the ground team member but will have a quadcopter operator working remotely. You will be performing the sweeping operation to identify and locate the target. The quadcopter operator will be providing information remotely to you during this operation. The drone will be used to enter each room to be swept before you.

3) Following the experiment, you will be asked to complete a post-experiment survey and an informal interview. The audio of the informal interview may be recorded.

These activities are expected to last 240 - 350 minutes.

Risks or Discomforts

You will not be engaging in tasks that exceed normal building sweeping operations as expected in standard Story County Sheriffs' Office training. You will only walk around the experiment area. The research team assumes the participant has had experience in building sweeping operations.

Benefits

If you decide to participate in this study, there may be no direct benefit to you. It is hoped that the information gained in this study will benefit society by providing valuable insights for human-robot interaction in team environments.

Costs and Compensation

You will not have any costs from participating in this study. You will not be compensated for participating in this study.

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Participant Rights

Participating in this study is completely voluntary. You may choose not to take part in the study or to stop participating at any time, for any reason, without penalty or negative consequences. You can skip any questions in the pre- and post-survey that you do not wish to answer.

If you have any questions *about the rights of research subjects or research-related injury*, please contact the IRB Administrator, (515) 294-4566, IRB@iastate.edu, or Director, (515) 294-3115, Office for Responsible Research, Iowa State University, Ames, Iowa 50011.

Research Injury

Injury will be treated following standard Story County Sheriff's Office protocol. The participant will be escorted immediately by one of the research team members to Mary Greely Medical Center and an injury report will be filed to the Story County Sheriff's Office.

Confidentiality

Records identifying participants will be kept confidential to the extent permitted by applicable laws and regulations and will not be made publicly available. However, federal government regulatory agencies, auditing departments of Iowa State University, and the Institutional Review Board (a committee that reviews and approves human subject research studies) may inspect and/or copy study records for quality assurance and data analysis. These records may contain private information.

To ensure confidentiality to the extent permitted by law, the following measures will be taken: participants' names will be replaced with their participant number and names will not be collected other than for informed consent reasons. Participant names will be associated with a code and key. Participant information will not be stored with the key and the key will be destroyed after data analysis has been completed. Only the research team will have access to the data and study records. Physical copies of the informed consent forms will be kept with one of the principal investigators and stored in a locked filing cabinet. The room of the principal investigator will be locked when the principal investigator is not in the room. The electronic data will be stored on a password protected external hard drive.

Audio recordings and field notes will be stored on an encrypted drive. Only the research team will have access to the encrypted drive. Specifics about the audio or who any identifying information will not be shared. Generalization of communications by all participants may be used for research purposes (i.e. 97% of participants developed a certain entry point plan, etc.).

Questions

You are encouraged to ask questions at any time during this study. For further information ***about the study***, contact one of the principal investigators: Thomas M. Schnieders (tms@iastate.edu) or Zhonglun Wang (zhonglun@iastate.edu). Alternatively, you may contact the supervising faculty: Dr. Richard T. Stone (rstone@iastate.edu).

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Consent and Authorization Provisions

Your signature indicates that you voluntarily agree to participate in this study, that the study has been thoroughly explained to you, that you have been given the time to read the document, and that your questions have been satisfactorily answered. You will receive a copy of the written informed consent prior to your participation in the study.

Participant's Name (printed) _____

_____ _____

Participant's Signature Date

Pre-Experiment Survey

The Effect of Human Robot Interaction on Trust, Situational Awareness, and Performance in Drone Sweeping Operations

Participant #: _____

Team #: _____

Demographics:

Age: _____

Gender: _____

Experience

Which agency do you work for?

Want special duties/operations have you been trained for or are currently serving (please list the number of years in each special operation)?

How many years have you been in law enforcement before special operations?

How much experience do you have with building sweeping operations?

How much experience do you have operating a quadcopter?

A. None
B. Tried it once
C. Tried it a few times
D. Lots of experience

Do you know any of team members who you will perform the task with for this study?

Have you ever participated in a tele-operational experiment before?

What is your motivation for participating in the experiment?

Post-Experiment Survey

The Effect of Human Robot Interaction on Trust, Situational Awareness, and Performance in Drone Sweeping Operations

Participant #: _____

Team #: _____

Task-Related Questions

1) How much involvement did you have in the decision making?

1	2	3	4	5
None				Made all the decisions

2) What was the process you followed to complete the task? If you used the quadcopter, please specify how/if you/your team took advantage of using the quadcopter.

3) Did you experience frustration during the task?

1	2	3	4	5
No				Yes, extremely frustrated

4) If so, why?

5) If you used the quadcopter, what were the pros and cons regarding the use of the quadcopter for this task?

6) If you didn't use a quadcopter, do you think having a quadcopter in the sweeping operation would have helped with this task?

1	2	3	4	5
No help				Huge Help

7) If so, why?

8) If you had to complete the task again, what, if anything, would you have done differently?

9) Please provide any additional comments you have about the experiment below.

SART 10D Rating Sheet

Instability of Situation

How changeable is the situation? Is the situation highly unstable and likely to change suddenly (high), or is it very stable and straightforward (low)?

Low ◆——————————————————————◆ High

Complexity of Situation

How complicated is the situation? Is it complex with many interrelated components (high) or is it simple and straightforward (low)?

Low ◆——————————————————————◆ High

Variability of Situation

How many variables are changing in the situation? Are there a large number of factors varying (high) or are there very few variables changing (low)?

Low ◆——————————————————————◆ High

Alertness

How alert are you in the situation? Are you alert and ready for activity (high) or do you have a low degree of alertness (low)?

Low ◆——————————————————————◆ High

Concentration of Attention

How much are you concentrating on the situation? Are you bringing all your thoughts to bear (high) or is your attention elsewhere (low)?

Low ◆——————————————————————◆ High

Division of Attention

How much is your attention divided in the situation? Are you concentrating on many aspects of the situation (high) or focused on only one (low)?

Low ◆——————————————————————◆ High

Spare Mental Capacity

How much mental capacity do you have to spare in the situation? Do you have sufficient mental capacity to attend to many variables (high) or nothing to spare at all (low)

Low ◆——————————————————————◆ High

Information Quality

How good is the information you have gained about the situation? Is the knowledge communicated very useful (high) or is it a new situation (low)?

Low ◆——————————————————————◆ High

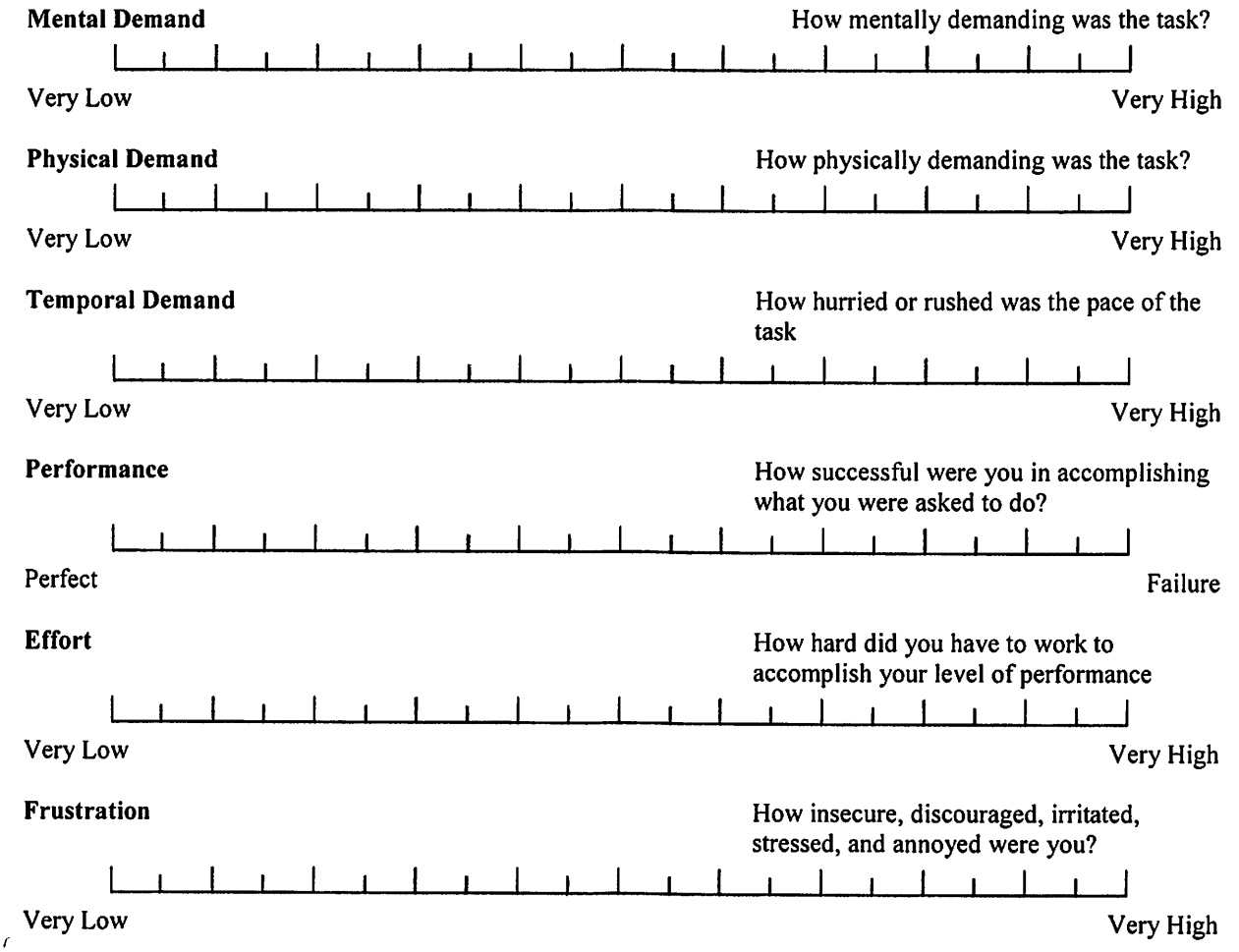
Familiarity with Situation

How familiar are you with the situation? Do you have a great deal of relevant experience (high) or is it a new situation (low)?

Low ◆——————————————————————◆ High

NASA Task Load Index

Hart and Staveland's NASA Task Load Index (TLX) method assesses work load on five 7-point scales. Increments of high, medium, and low estimates for each point result in 21 gradations on the scale.



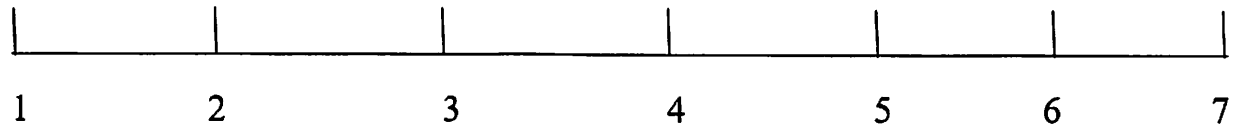
Trust in Human-Robotic Interaction

Below is a list of statements for evaluating trust between people and automation. There are several scales for you to rate intensity of your feeling of trust, or your impression of the quadcopter during the operation.

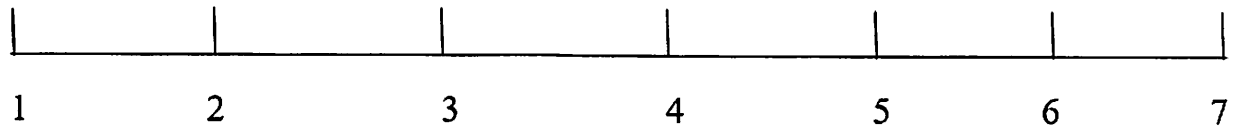
Please mark an 'x' on each line at the point which best describes your feeling or your impression.

(Note: 'not at all' = 1, 'extremely' = 7)

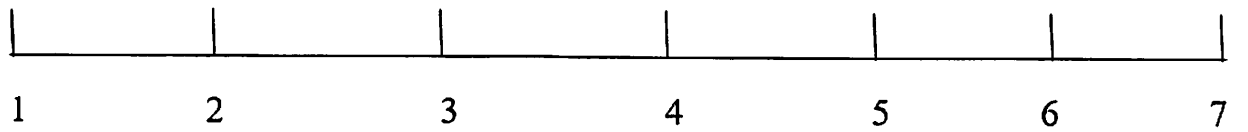
1. The system is deceptive



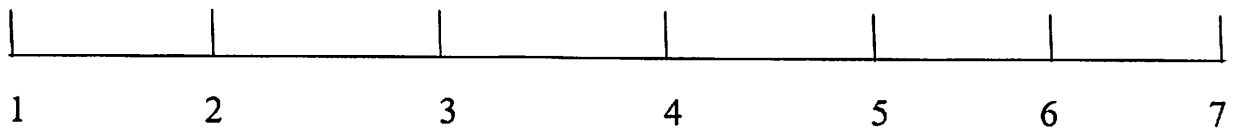
2. The system behaves in an underhanded manner



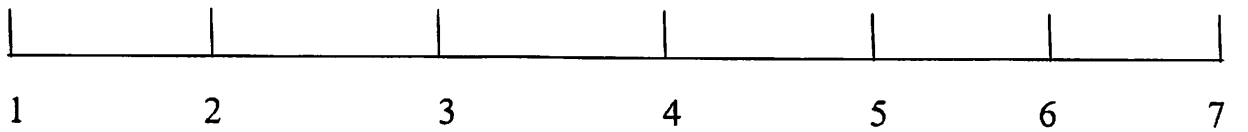
3. I am suspicious of the system's intent, action, or outputs



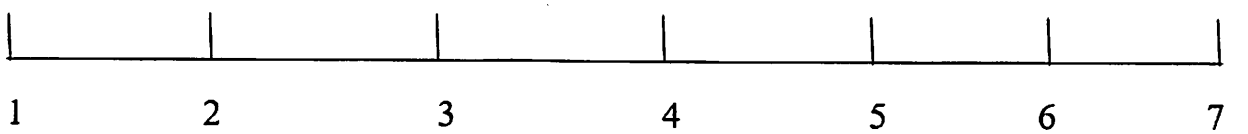
4. I am wary of the system



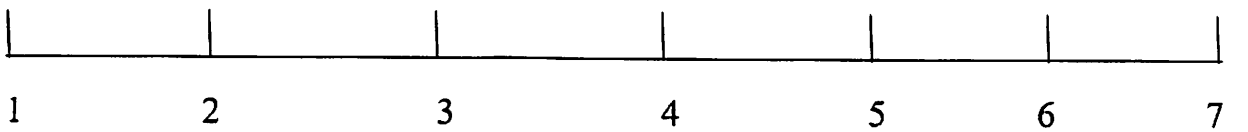
5. The system's actions will have a harmful or injurious outcome



6. I am confident in the system



7. The system provides security



8. The system has integrity

1 2 3 4 5 6 7

9. The system is dependable

1 2 3 4 5 6 7

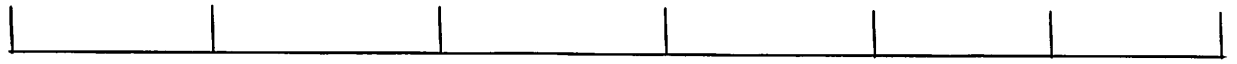
10. The system is reliable

1 2 3 4 5 6 7

11. I can trust the system

1 2 3 4 5 6 7

12. I am familiar with the system



1 2 3 4 5 6 7

Informal Interview

The Effect of Human Robot Interaction on Trust, Situational Awareness, and Performance in Drone Sweeping Operations

1) How accurate do you think the information provided to you was?

2) Would you trust a drone to 'have your back' during a real world sweeping operation? Why or why not?

3) In what kind of situations would you be okay having a drone assist you?

4) How comfortable would you be always doing sweeping operations with just you and the remotely controlled drone?

5) What if that drone was automated?

Additional comments and notes:

Debriefing

The Effect of Human Robot Interaction on Trust, Situational Awareness, and Performance in Drone Sweeping Operations

Thank you all for participating in our study!

For this study, we are investigating how drones can influence police building clearing performance.

We provided a scenario for you and asked to perform building clearing operation. Your team completed the task within ____ minutes and answered the questions we asked. All those data we collected and will be analyzed to understand the effect of human-robot collaboration for police building clearing performance.

Again, we will alter any information regarding your identity. The recordings will be kept on Cybox and the paper documents will be locked to the cabinet at 0066 Black Engineering.
If you have any concern about the experiment, please feel free to send email or give us a call."