2018

Assessing the Role of Critical Value Factors (CVFs) on Users' Resistance of Urban Search and Rescue Robotics

Marion A. Brown
Nova Southeastern University, marion.a.brown@gmail.com

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by

Marion A. Brown

A dissertation submitted in partial Fulfillment of the requirements
for the Degree of Doctor of Philosophy
in
Information Systems

College of Engineering and Computing
Nova Southeastern University

2018

We hereby certify that this dissertation, submitted by Marion Brown, conforms to acceptable standards and is fully adequate in scope and quality to fulfill the dissertation requirements for the degree of Doctor of Philosophy.

Yair Levy, Ph.D. — Date 6/12/2018
Chairperson of Dissertation Committee

James L. Parrish, Ph.D. — Date 6/12/2018
Dissertation Committee Member

Marlon Clarke, Ph.D. — Date 6/12/2018
Dissertation Committee Member

Approved:

Yong X. Tao, Ph.D., P.E., FASME — Date 6/12/2018
Dean, College of Engineering and Computing

College of Engineering and Computing
Nova Southeastern University

2018

An Abstract of a Dissertation Submitted to Nova Southeastern University
in Partial Fulfillment of the Requirements for the Degree of Doctor of Philosophy

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June 2018

Natural and manmade disasters have brought urban search and rescue (USAR) robots to the technology forefront as a means of providing additional support for search and rescue workers. The loss of life among victims and rescue workers necessitates the need for a wider acceptance of this assistive technology. Disasters, such as hurricane Harvey in 2017, hurricane Sandy in 2012, the 2012 United States tornadoes that devastated 17 states, the 2011 Australian floods, the 2011 Japan and 2010 Haiti earthquakes, the 2010 West Virginia coal mine explosions, the 2009 Typhoon caused mudslides in Taiwan, the 2001 Collapse of the World Trade Center, the 2005 Hurricane Katrina, the 1995 Oklahoma City bombing, and the 1995 Kobe Japan earthquake all benefited from the use of USAR. While there has been a push for use of USAR for disaster, user resistance to such technology is still significantly understudied.

This study applied a mixed quantitative and qualitative approach to identify important system characteristics and critical value factors (CVFs) that contribute to team members' resistance to use such technology. The populations for this study included 2,500 USAR team members from the Houston Professional Fire Fighters Association (HPFFA), and the expected sample size of approximately 250 respondents.

The main goal of this quantitative study was to examine system characteristics and CVFs that contribute to USAR team members' resistance to use such technology. System characteristics and CVFs are associated with USAR. Furthermore, the study utilized multivariate linear regression (MLR) and multivariate analysis of covariance (ANCOVA) to determine if, and to what extent, CVFs and computer self-efficacy (CSE) interact to influence USAR team members' resistance to use such technology.

This quantitative study will test for significant differences on CVF's, CSE, and resistance to use such technology based on age, gender, prior experience with USAR events, years of USAR experience, and organizational role. The contribution of this study was to reduce USAR team members' resistance to use such technology in an effort minimize risk to USAR team members while maintaining their lifesaving capability.

Acknowledgements

My doctoral journey was anything but typical. My family has been my greatest inspiration and a consistent anchor to prevent me from losing my way. I would like to thank my wife Kristi and my friend Jeff for their relentless support, encouragement, and kind words throughout my doctoral journey. There were days when I would have given up were it not for you.

To my children, Cameron and Ashley, I have always told you to be better than me. I hope that watching me pursue my doctorate has provided you with some perspective on your path ahead as you pursue higher education. The road is not easy, and if it was, it would not be worth traveling. I love both of you dearly.

I would like to thank my expert panel for their support and timely submissions, without your input, this endeavor would not be possible. Your commitment to excellence in the research community is greatly appreciated. Additionally, I would like to thank the HPFFA for your willingness to participate in this research study. Thank you for everything that you do on a daily basis for our community.

I would particularly like to thank my dissertation advisor, Dr. Levy for support, leadership, discipline, and encouragement. You believed in me and the value of my work even when I did not. You allowed me to meet and understand adversity in ways that I did not know existed. You gave me inspiration, comfort, and you taught me determination. As I move forward, I will relish and appreciate our friendship and research collaboration. Additionally, I would like to thank my dissertation committee members Dr. Marlon Clarke and Dr. James Parrish for your timely feedback, insightful commentary, and wise advice throughout the dissertation process.

Table of Contents

List of Tables

Tables

List of Figures

Figures

Chapter 1

Introduction

Background

Recent and past devastations have brought urban search and rescue (USAR) robots to the technology forefront as an assistive technology for search and rescue workers (Casper, Micire, & Murphy, 2000). USAR robot technology can save victims lives without risking the life of the urban search and rescue worker (Murphy, Casper, & Micire, 2001). Casper et al. (2000) noted that during the 1985 Mexico City earthquake, 135 rescuers died while searching for earthquake victims. Even with the documented catastrophic loss of life of rescue workers during disaster events, Legris, Ingham, and Collerette (2003) noted that USAR robots have not been widely accepted by search and rescue workers. Moreover, they noted that additional research is required to identify the characteristics of the USAR robot systems that are important to USAR team members in order to mitigate their resistance to such robotic systems. The remainder of this document includes a problem statement and goal, research goals of the study, research questions, as well as the hypotheses that this study intends to investigate.

Problem Statement

The research problem that this study addressed is the struggle that USAR team members have during a disaster to save victims' lives without sacrificing their own lives (Murphy et al., 2001). A USAR robot system is defined as a device that automatically, or via remote control, is capable to search, extract, examine, or inspect the surroundings of a disaster site for the purpose of collection, processing, storing, displaying, as well as dissemination of information to USAR team members (Burke, Murphy, Rogers, Scholz,

& Lumelsky, 2004; Casper & Murphy, 2003; Drury, Yanco, & Scholtz, 2005). According to Murphy (2000) and Casper et al. (2000), USAR is a dangerous endeavor often resulting in the unnecessary loss of victim and rescue workers lives. Blitch (1996) further clarified that USARs operate in domains that are too dangerous for human rescuers, poses an almost infinitely difficult spectrum of challenges, and yet, provides an opportunity for robots to play a pivotal support role in saving lives.

During disasters, USAR robots provide opportunities to save human lives while protecting USAR team members in a variety of disasters, such as 2017 hurricane Harvey, 2012 hurricane Sandy, the 2012 United States tornadoes that devastated 17 states, the 2011 Australian floods, the 2011 Japan earthquakes, the 2010 West Virginia coal mine explosions, the 2009 Typhoon in Taiwan, the 2001 Collapse of the World Trade Center, and the 1995 Oklahoma City bombing. Murphy (2000) noted that USAR robot systems research has been ongoing since 1996, but after more than a decade of research, Bishop, Crabbe, and Hudock (2005) suggested that additional research be conducted to develop more interactive USAR robots. Casper and Murphy (2003) explained that due to the dangerous and time-sensitive nature of USAR, researchers have not had the opportunity to validate the specific characteristics that make USAR robots valuable to USAR team members during disaster events. Messina and Jacoff (2006) defined USAR robot system characteristics as components of the USAR robot system, which facilitate interaction, sensory, mobility, as well as communication capabilities that assist an operator in the act of victim location and recovery during a USAR disaster event.

Based on research conducted during three workshops from 2004 to 2005, Messina, Jacoff, Scholtz, Schlenoff, Huang, Lytle, and Blitch (2005) developed an initial set of requirements to guide the performance of USAR robots. The requirements from Messina et al. (2005) focused on the robot's hardware, while ignoring the importance of the user experience component, including their potential resistance and the perceived value of the USAR robots during a disaster event. The definition of cognitive value is "an enduring core belief about the level of importance users attribute to a system" (Rokeach, 1969, p.160). Khale and Kennedy (1988) suggested that previous studies failed to measure the users' perceived value, without consideration of the value's context, which is an important influence on behavior that may be missed. Kim and Kankanhalli (2009) defined user resistance as, "an opposition of a user to change associated with a new IS implementation" (p. 568). Marakas and Hornik (1996) cited resistance as a behavioral response to threats associated with the use of a new system. USAR team members' resistance to use USAR robots, and the factors that inhibit such resistance, formed the basis of this research study.

Paton and Flin (1999) noted that when individuals experienced emergency stressors during disasters or other critical incidents, such as natural disasters, manmade disasters, or terrorism, many reacted differently in each situation. Paton and Flin (1999) suggested that stressors could inhibit a USAR team member's ability to perform during a disaster situation. Therefore, the issue of computer self-efficacy (CSE) is a potential covariate in a study of robot use resistance. Compeau and Higgins (1995) defined CSE as "a judgment of one's capability to use a computer" (p. 192). This definition was based on previous, more generalized self-efficacy work by Bandura (1986), in which he defined self-efficacy as "People's judgments of their capabilities to organize and execute courses of action required to attain designated types of performances" (p. 391). Moreover, CSE in the context of USAR robots research refers to an individual's belief about their ability to use such robots to locate victims in a rubble pile. Burke et al. (2004) noted that during disaster operations, USAR team members experienced sporadic, brief, and intense interactions that created an atmosphere of pressure, which ultimately resulted in increased stress levels. However, limited research exists regarding USAR team members' resistance of robotic systems for disaster operations. Ahituv, Munro, and Wand (1981) asserted that identifying systems is not sufficient. Each tool must be evaluated for its benefit to the operation in order to determine its value as part of the overall perceived cognitive value of the system to the user.

Levy, Murphy, and Zanakis (2009) defined user-perceived value as "a belief about the level of importance that users hold for [Information Systems (IS)] characteristics" (p. 94). Zeithaml (1988) suggested that perceived value is the users' overall assessment of the utility of a product based on perceptions of what is received and what is given. Ahituv et al. (1981) also noted that there is no widely accepted methodology to determine the value of systems, thus, in practice the identification of value is often neglected, though its significance cannot be underestimated. Keeney (1999) noted that the perceived value of a user is a key determinant to whether a user accepts or rejects a system. Technology adoption and use are a function of perceived value of the information, and understanding the value of that information allows developers to improve the system (Rafaeli & Raban, 2003). Additionally, Keeney (1999) suggested that it would be ideal to collect a sample set of system characteristics that represent value to the user. While a particular USAR may contain many valuable system characteristics, some system characteristics were more valuable than others were. According to Levy

(2008), critical value factors (CVFs) are the factors of the system characteristics that individuals view as important in increasing their perceived value. Thus, more research is required to determine if similar perceived value exist in USAR based on CVFs in that domain.

Dissertation Goal

The main goal of this quantitative study was to examine system characteristics and critical value factors (CVFs) that create resistance to the use of robots by USAR members. Based on work by Keeney (1999), the first specific goal of this study was to identify the USAR robot system characteristics that USAR team members perceived to be important during disaster operations. The significance of the construct of importance, i.e. perceived value, should be considered a critical component in the assessment of any IS (Rafaeli & Raban, 2003). The second goal of this quantitative study was to identify CVFs of the USAR robot system characteristics perceived by USAR team members to be important during disaster operations.

Durgee, O'Connor, and Veryzer (1996) suggested that the best way to determine perceived value (PV) of a system is to ask the user about their feelings. Durgee et al. (1996) openly admitted that this method exhibits some weakness. Additional research was required to identify CVFs in general, while uncovering it in the context of USAR team members can address the required need in this highly specialized environment. The third goal of this research was to empirically assess the contribution of the CVFs as well as CSE to USAR search and rescue workers' resistance (RES). This study built on previous research that investigated key system characteristics, CVFs, and PV of IS (Casper et al., 2000; Legris et al., 2003; Levy, 2003; Corder & Foreman, 2009). The fourth specific goal of this study was to investigate if there were any significant differences in the measured constructs: CVFs, CSE, and RES during disaster operations, based on (a) age, (b) gender, (c) prior experience with actual USAR events, (d) years of USAR work experience, and (e) organizational role. Several studies suggested that factors such as age, gender, self-efficacy, organizational role, and prior experience with such specialized robots may affect a user's perceived USAR system value.

Kooij, van Alem, Koster, and de Vos (2004) suggested that police officers, regardless of age, are capable of being trained to use automated devices. Additionally, de Vries, Alem, Vos, Oostrom, and Koster (2005) demonstrated that police officers with a mean age of 35 were competent using automated devices. Thus, this research attempted to determine if there were any significant differences on the measured constructs based on age. Qureshi, Gershon, Sherman, Straub, Gebbie, McCollum, and Morse (2005) observed that both gender and childcare responsibilities negatively correlated with the willingness of staff to work effectively during a disaster event. Qureshi et al. (2005) also noted that female workers exhibited a lower likelihood of being willing to report to duty and be productive during a catastrophic disaster event. Therefore, this research explored whether there are any significant differences on the measured constructs based on gender during a disaster event using a self-report measure rather than during an actual disaster event. Thus, this research study examined whether a USAR team members' CSE contributes significantly to team members' resistance of USAR systems. Organizational role contributes to an individual's level of stress (Ahmady, Changiz, Masiello, & Brommels, 2007). Results showed that individuals suffered from role overload, role expectation conflict, inter-role distance, role inadequacy, role stagnation, and role isolation. VanDevanter, Leviss, Abramson, Howard, and Honore (2010) revealed that during an emergency response, the organizational role of first responders plays a vital part in the management of disaster situations.

VanDevanter et al. (2010) also noted that organizational roles continue to evolve and suffer from numerous challenges, such as clear articulation of roles within the public during disaster events. Thus, this research sought to determine if there were any significant differences on the measured constructs based on USAR team members' organizational role. Prior experience facilitated quicker and calmer actions when working with victims in a disaster event and served as a substitute for training. (Gershon, Qureshi, Rubin, & Raveis, 2007). Furthermore, Gershon et al. (2007) cited individual and collective knowledge as facilitators for an efficient evacuation during a disaster event. Users with little experience in the USAR domain would have difficulty performing authentic USAR tasks with a USAR robot in a disaster situation (Yanco & Drury 2004). Yanco and Drury (2004) also noted that USAR workers with minimal prior experience struggled to gain effective control of USAR robots. Thus, the quantitative study aimed to identify differences between USAR team members' with and without prior experience with USAR robots. A predictive model will be developed to assess the contribution of the CVFs and CSE on RES during disaster operations. Using a predictive model to measure value was an effective method to identify a user's tendency to choose the most valued option when multiple alternatives existed (Dyer & Sarin, 1979).

Research Questions and Hypotheses

The main research question (RQ) that this study addressed was the following: What are the important system characteristics and their CVFs that contribute to USAR team members' RES? The specific research questions that this study addressed were:

RQ1: What are the USAR robot system characteristics that are important for USAR team members when using specialized robots?

RQ2: What are the CVFs of the USAR system characteristics?

RQ3: What is the contribution of CVFs and CSE on USAR team members' RES?

RQ4: What is the contribution of the interaction between CVFs and CSE on USAR team members' RES?

RQ5: Are there any significant differences on CVFs, CSE, and RES based on age, gender, prior experience with USAR events, years of USAR experience, and organizational role?

The specific hypotheses this study addressed were:

H_o1: There are no statistically significant contribution of USAR team members' Critical Value Factors (CVFs) to their Resistance to use USAR Robots (RES).

H_o2: There are no statistically significant contribution of USAR team members' Computer Self-Efficacy (CSE) to their Resistance to use USAR Robots (RES).

H_o3: There are no statistically significant contribution of the interaction effect between USAR team members' Critical Value Factors (CVFs) and Computer Self-Efficacy (CSE) to their Resistance to use USAR Robots (RES).

H_o4a: USAR team members' Resistance to use USAR Robots (RES) are not statistically significant differ among their Critical Value Factors (CVFs) and Computer Self-Efficacy (CSE), when controlled for age.

H_o4b: USAR team members' Resistance to use USAR Robots (RES) are not statistically significant differ among their Critical Value Factors (CVFs) and Computer Self-Efficacy (CSE), when controlled for gender.

H_o4c: USAR team members' Resistance to use USAR Robots (RES) are not statistically significant differ among their Critical Value Factors (CVFs) and Computer Self-Efficacy (CSE), when controlled for prior participation in live USAR event (PLE).

H_o4d: USAR team members' Resistance to use USAR Robots (RES) are not statistically significant differ among their Critical Value Factors (CVFs) and Computer Self-Efficacy (CSE), when controlled for their years of USAR work experience (EXP).

H_o4e: USAR team members' Resistance to use USAR Robots (RES) are not statistically significant differ among their Critical Value Factors (CVFs) and Computer Self-Efficacy (CSE), when controlled for their organizational role (ORG). Figure 1 represents the conceptual model for the predictive phase of this study.

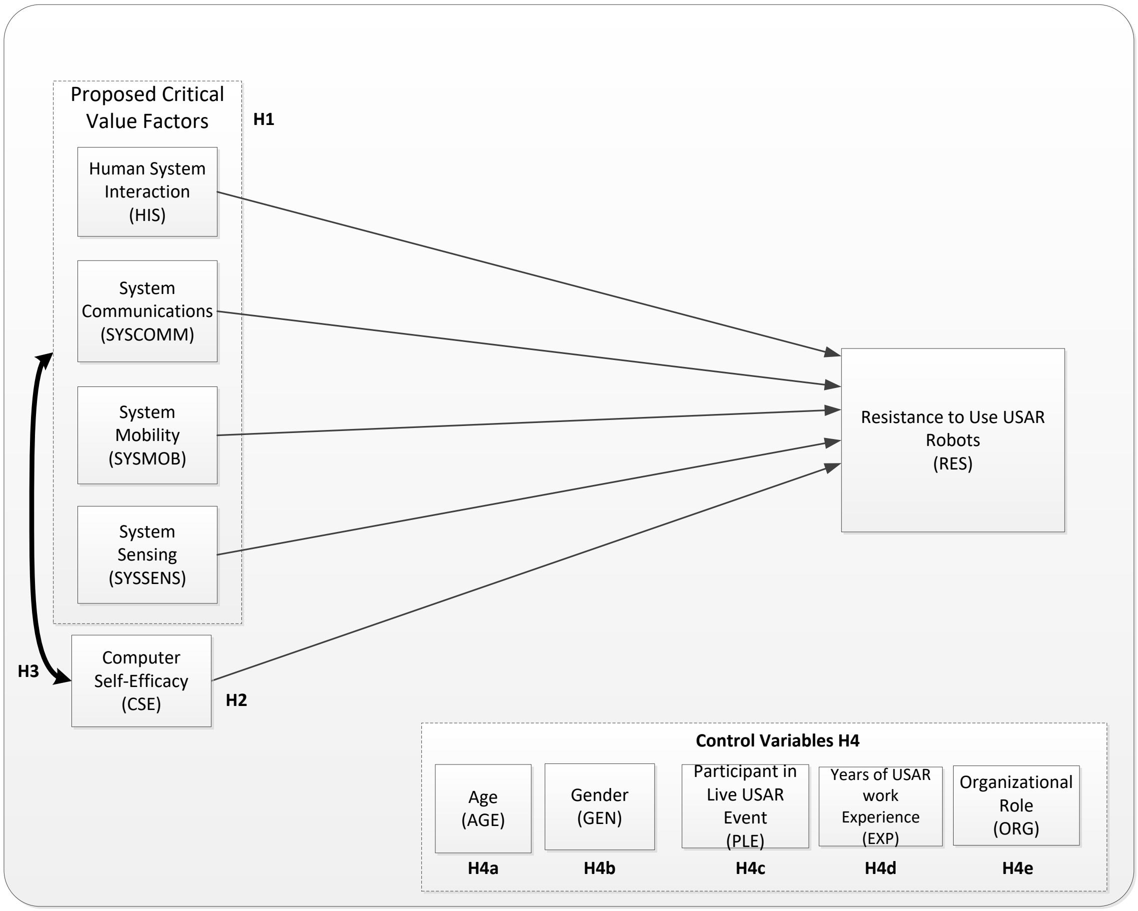

Figure 1. Conceptual research map to users' resistance of technology adoption.

Relevance and Significance

Relevance. The study was relevant, as it sought to facilitate a better understanding of the role of CVF's on users' resistance to urban search and rescue robotics. Legris et al. (2003) noted that robots have not been widely accepted by search and rescue workers. Thus, additional work was required to identify the characteristics of USAR robot systems that are important to USAR team members in order to reduce workers' resistance to robotic systems. A review of the literature revealed few studies that focused on CVFs as they relate to users' resistance of USAR robotics (Blitch, 1996;

Bishop et al., 2005; Messina & Jacoff, 2006). As USAR events occur, the need for a solution that prevents additional loss of life while saving victims becomes relevant.

Significance. This research is significant, as it will advance current research in Information Management and robotics and facilitate an increase in the body of knowledge regarding IS users' behavior as it relates to CSE, CVFs, and RES. Ahituv et al. (1981) explained that identification of USAR systems required to find victims is not a sufficient endeavor; each tool must be evaluated for its benefit to the operation to determine value. Keeney (1999) noted that perceived value of a user is a key determinant for acceptance or rejection of an Information System.

Barriers and Issues

One potential barrier is that permission to survey search and rescue workers, as well as IRB approval, is needed to use rescue workers as survey participants. Approval to conduct the study was obtained prior to pursing IRB approval.

Assumptions, Limitations, and Delimitations

Assumptions. The primary study assumption was that participants would answer interview and survey questions honestly and without and social bias.

Limitations. A limitation of the study was related to participants' experience with USAR robots. The population of experienced first responders with USAR robot experience is low.

Delimitations. The study limited the survey participants to a single firefighters union in a specifc city and state's first responder population.

Definition of Terms

Cognitive value. An enduring core belief about the level of importance users attribute to a system (Rokeach, 1969, p. 160).

Computer Self-Efficacy (CSE). A judgment of one's capability to use a computer. CSE in the context of USAR robots research is defined as an individual's belief about their ability to use such robots to locate victims in a rubble pile (Compeau & Higgins, 1995, p. 192).

Critical Value Factors (CVFs). The factors of the system characteristics that individuals view as important in order to increase their perceived value (Levy, 2008).

Self-Efficacy. People's judgments of their capabilities to organize and execute courses of action required to attain designated types of performances (Bandura, 1986).

Urban Search and Rescue (USAR). A branch of rescue that concentrates on victim detection and removal from man-made structures, such as collapsed buildings after disasters (Osuka, Murphy, & Schultz, 2002, p. 26).

Urban Search and Rescue Robot System. A device which automatically or via remote control has the ability to search, extract, examine, or inspect the surroundings of a disaster site for the purpose of collection, processing, storing, displaying, as well as disseminating information to USAR team members (Burke et al., 2004).

User Resistance. An opposition of a user to change associated with a new IS implementation (Kim & Kankanhalli, 2009, p. 568).

User-Perceived Value. A belief about the level of importance that users hold for characteristics (Levy et al., 2009, p. 94).

Summary

Devastation, both natural and manmade, necessitate the rescue of human life. However, these rescues also pose a threat for USAR workers attempting to retrieve survivors from urban disaster sites. USAR robots have the potential to aid in the saving of victims while preserving the lives of USAR workers (Murphy et al., 2001). USAR robot technology can aid in the survival of those working at urban disaster sites through the collection, processing, and displaying of data, as well as through the dissemination of data to all USAR team members (Burke et al., 2004).

The willingness of USAR members to adopt robots into their practice may rely on critical factor values and perceptions of computer self-efficacy. This mixed methods quantitative study tested for relationships between variables and their influence on a USAR team members' willingness to adopt robots as part of USAR missions. Qualitative data was acquired through open-ended questionnaires distributed among members of an expert panel, and quantitative survey data collected from USAR team members. The next chapter examines the literature regarding USAR robot history, USAR robot use, critical value factors, and computer self-efficacy.

Chapter 2

Review of the Literature

Utilizing robots in USAR is a fascinating possibility that deserves careful consideration although there is certain resistance to any new technological change implemented in to a job. This literature review delves into the Resistance literature to provide an understanding of why user resistance is important. The literature then discusses the CVFs associated with USAR and why CVFs are an important in the context of user resistance. Finally, the literature review discusses computer self-efficacy and its relationship to CVFs and RES.

Urban Search and Rescue Robotics

In 2012, the Human Robot Interaction (HRI) Organization identified USAR as the highest profile HRI research area in the United States. This importance has led to USAR becoming an HRI challenge problem. The notion of robots has existed for centuries. The first remotely operated device was created by Nicola Tesla in 1898 as a radio-controlled boat (Turi, 2014). Whitcomb (2000) recounts the Naval Research Laboratory's "Electric Dog", seen in Figure 2, which precipitated attempts to remotely pilot bombers during World War II and ultimately led to the creation of remotely piloted vehicles such as the predator seen in figure 4; an unmanned aerial vehicle in use today for military and research purposes worldwide. Between Tesla's boat and the predator are more common drones used by researchers or novice enthusiast. Figure 3 shows a group of retail drones suitable for entry level or professional users.

The most commonly cited example of an early autonomous robot was Shakey, capable of navigating through a black world under carefully controlled lighting conditions at the glacially slow speed of approximately 2 meters per hour (Nilsson, 1984). Researchers agree that these early works laid a foundation for much that goes on in hybrid control architectures today (Murphy, 2000; Parker, 1998).

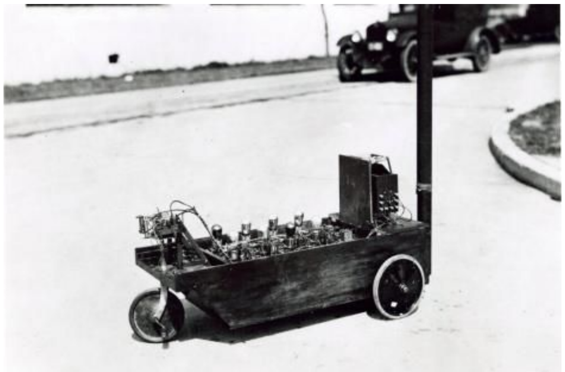

Figure 2. Naval Research Labs “Electric Dog” 1923.

Goodrich and Schultz (2007) noted that although robot technology was primarily developed in the mid and late 20th century, it is important to remember that the notion of robot-like behavior and its implications for humans have been around for centuries in

Figure 3. Retail drones: a) aerial photography, b) basic trainer, c) racing drone.

religion, mythology, philosophy, and fiction. Robots have had a large presence in science fiction literature, most notably Asimov’s works (1986). Asimov’s Laws of Robotics appear to be the

Figure 4. Predator unmanned vehicle.

first designer guidelines for human robotic interaction. As technology evolved, the capabilities of remotely operated robots have grown (Fong and Thorpe, 2001). Whitcomb (2000) provided practical applications for unmanned vehicles in the context of underwater vehicles used to explore the ocean's surface, exploring underwater life, underwater construction, and the study of geothermal activity.

Fong and Thorpe (2001) believed that the development of robust robot platforms and communications technologies for extreme environments has been accomplished by NASA and other international space agencies. Space agencies have had several high profile robotic projects designed with an eye toward safely exploring remote planets and moons. Examples include early successes of the Soviet Lunokhods (Fong & Thorpe, 2001) and NASA's more recent success of exploring the surface of Mars (Leger, Trebi-Ollennu, Wright, Maxwell, Bonitz, Biesiadecki, Hartman, Cooper, Baumgartner, & Maimone, 2005; Wilcox & Nguyen, 1998). Robonaut, seen in figure 5, is an example of successful teleoperation of a humanoid robot (Ambrose, Aldridge, Askew, Burridge, Bluethmann, Diftler, Lovchik, Magruder, & Rehnmark, 2000). This work is being extended at a rapid pace to include autonomous movement and reasoning.

Figure 5. NASA Robonaut.

USAR involves the rescue of victims from the collapse of a man-made structure (Burke & Murphy, 2004). Burke and Murphy (2004) further explain that the environment can be characterized as a pile of steel, concrete, dust, and other rubble and debris. The areas are perceptually disorienting; they no longer look like recognizable structures due to the collapse, it is dark, and everything is covered in gray dust from concrete or sheet rock. A critical need for robots during a disaster is the conceptual basis for the field of USAR. USAR is a branch of first response that concentrates on victim detection and removal from man-made structures, such as collapsed buildings after an earthquake (Osuka, Murphy, & Schultz, 2002). Rescue workers have a narrow window of time in which to find and rescue victims. Robots can assist in this task by assuming the risk of going into places inaccessible or dangerous to USAR workers (Murphy, 2000). There is an ongoing need for robots in USAR scenarios. The robots used for the Twin Towers disaster were not originally developed for that task, but their use showed the possibilities of robotics in USAR (murphy, 2000). Initially, companies such as Inuktun Services Ltd. and American Standard Robotics were pushed to the forefront of robot assisted search and rescue at a dark time in our nation's history.

Resistance

IS models have been developed since the early 1970's. These include the Theory of Reasoned Action (TRA) (Fishbein and Ajzen, 1975), Technology Acceptance Model (TAM) (Davis, 1989), Theory of Planned Behavior (Ajzen, 1991), DeLone and McLane IS Success Model (DeLone & McLane, 1992), and task-technology fit (Goodhue & Thompson, 1995). All of these models sought to identify perceived usefulness based on the use of technology (Norzaidi, Chong, & Salwani, 2008). Norzaidi et al. (2008) implied that there was a significant gap in knowledge regarding the identification of the causes of rejection to the use of technology in terms of user resistance and perceived resistance. Norzaidi et al. (2008) also documented that user resistance is unavoidable to management and generally causes performance to appear lower than expectations. Ultimately, the result of this resistance is organizational technology failure and loss of investment (Joshi 2005; Norzaidi & Intan-Salwani, 2007). Gibson (2003) and McAfee (2004) revealed that up to 70% of IS implementation projects fail. Clegg, Axtell, Damadoran, Farbey Hull, Lloyd-Jones, Nichols, Sell, and Tomlinson (1997) stated that 80-90% of IS implementation projects fail to meet their objectives. Chen, Law, and Yang (2009) further stated that the failure rate of enterprise systems implementation is particularly high.

Bates, Leape, Cullen, Laird, Peterson, and Teich (1998) believed that resistance in healthcare is a common phenomenon. After conducting a study with 602 patients over six weeks, Grupper and Brezis (2005) confirmed the underutilization of peri-operative beta-blockers among medical staff in an academic hospital in Israel. The results of the study concluded that even after intervention presentations and local evidence proved value for the use of beta-blockers, surgeons were resistant in prescribing orders because they felt the problem was for cardiologists, internists, or anaesthesiologists. Grupper and Brezis (2005) suggested the need for computer-based system to manage the decision making process to improve efficiency. In a 250-bed pediatric hospital, Baldwin (2010) showed that poor communication in the implementation stage of a security rollout could cause user resistance. In this case, 1200 laptops needed to be encrypted to protect patients' privacy to comply with government mandates. Baldwin (2010) noted that insufficient training caused users to become resistant to implementation due to unintuitive software.

User resistance was minimized thru circulation of emails, presentations across the hospital, providing cheat sheets on how to use the program, and video demonstrations of how to use the program. The outcome of the resistance countermeasures were strong relationships between the medical staff and the Information Technology (IT) department. For example, physicians at Cedars-Sinai Medical Center rebelled against their new computerized physician order entry (CPOE) system amidst complaints that the system was a distraction from medical duties. This resistance led to a complete uninstall after the system was already installed to 580 of the 870-bed hospitals devices (Freudenheim, 2004). In the organizational development domain, Lewin (1947) research provide early thoughts on user resistance with concepts of status quo, which is a form of resistance that allow users to revert to an original state. Zaltman and Duncan (1977) had similar ideas in that resistance to change was manifested in any conduct that sought to maintain the status quo even in the face of pressure. It should be noted that Lewin (1947) believed that resistance was not just a mirror image of acceptance or a behavior, rather it is a cognitive force that precludes behavior. Therefore, resistance is possibly an antecedent to IT acceptance and must be overcome to obtain a successful IT implementation (Bhattacherjee & Hikmet, 2007).

Cenfetelli (2004) argued that not only is resistance an antecedent of IT usage, but he concluded that inhibitors are negative factors that discourage IT usage when presented. Additionally, Cenfetelli noted that while IT acceptance is best predicted by enablers, IT rejection is best predicted by inhibitors. To explore this concept, Bhattacherjee and Hikmet (2007) surveyed 700 practicing physicians in a hospital setting. The survey was administered in two rounds and 131 responses were obtained, which represented a 19% response rate. According to Bhattacherjee and Hikment (2007), this study was one of the earliest to integrate the notion of user resistance in a unified model for IT usage. Their findings also noted that the body of knowledge was expanded by advancing the understanding of inhibiting perceptions of usage such as user resistance. While resistance is usually an overt concept, Marakas and Hornik (1996) suggested that there is a more covert type of resistance known as passive resistance. This type of resistance usually results from fear and stress due to the implementation of a technology that did not exist in a prior situation (Marakas & Hornik, 1996).

Kim and Kankanhalli (2009) conducted a study that investigated resistance to a new information system within an organizational setting. Status quo issues, or bias experienced on the part of users who disliked change and therefore resisted new technology was of interest. Kim and Kankanhalli (2009) conducted a field survey of users of a new enterprise system within a target organization consisting of 5,800 employees. The findings from Kim and Kankanhalli (2009) indicated that switching costs affected user resistance; uncertainty costs represent the psychological uncertainty of adopting a new technology. They indicated that there is a research gap in the understanding of how users evaluate change regarding a new information system. Conclusions of the findings revealed that switching costs and organizational support for change had a significant impact on user resistance. These findings are in line with Venkatesh (2000) as well as Joshi (1991) and Keen (1981). Jiang, Muhanna, and Klein (2000) conducted a study that investigated the connection between resistance reasons and system types in the context of system types. Jiang et al. (2000)'s study surveyed 66 managers via questionnaire across a variety of organizations. The aim of their study was to explicitly identify reasons for user resistance according to system type in an attempt to promote acceptance. The findings from Jiang et al. (2000) indicated that there are significant differences in the reasons that users resist systems, in this case transaction processing systems (TPS) in comparison to decision support systems (DSS). These results are consistent with literature, Aldelman (1992) as well as Jiang and Klein (1996) that evaluated the impact of systems on users' decision making. Additionally, their study suggested that irrespective of system type, participative strategies are most desired by subjects; collaboration is desired over isolation.

Norzadi, Salwani, and Chong (2008) evaluated perceived user resistance, user resistance, and managers' performance by leverage 357 middle managers in the port industry of Malaysia. All managers had experience using intranets that dated back to the early 2000's. The response rate for the study was 42% given that 150 responses were returned. The results revealed that task-technology fit was significantly related to usage and perceived use, as well as perceived resistance was a predictor of usage (Norzadi et al., 2008). Ultimately, Norzadi et al., (2008) surmised that there is no relationship between usage and user resistance. Resistance to change can even be seen in the digital library space (Nov & Ye, 2008). After surveying 244 students and receiving 170 usable responses or a 70% response rate, Nov and ye (2008) revealed that resistance to change is domain-specific and a determinant of users perceived ease of use. This research improved the body of knowledge by removing a common limitation of reliance on retrospective surveys (Venkatesh, Morris, Davis, & David, 2003). This is significant in that users' beliefs regarding a new system's characteristics at a specific point of time is critical to user adoption (Nov & Ye, 2008).

While user resistance is typically not framed as good or bad (Ferneley & Sobreperez, 2006; Lapointe & Rivard, 2005), resistance is not well received or valued in most organizational environments (McGrath, 2006; Willmott, 1993). This introduces a common notion that user resistance must be mitigated for functional outcomes to be realized (Selander & Henfridsson, 2012). Seminal literature by Markus (1983) theorized that better theories of resistance were required to enable better IT implementation strategies. Since then, significant attention has been given to user resistance, but only at a surface level (Lapointe & Rivard, 2005). It should be noted that other than Markus' (1983) research, only three additional papers (Joshi, 1991; Marakas & Hornik, 1996; Martinko, Zmud, & Henry, 1996) have proposed theoretical explanations for how and why resistance occurs. Joshi (2005) further noted that many implementation efforts fail due to resistance or non-acceptance of new systems by their user base. Yet, Delone and

McLean (1992) as well as Lucas, Ginzberg, and Schultz (1991) still suggested that for IT to be effective, it must be used. This concept is evidenced by user's resistance to participate in multi-hop communications networks where participation is required for the network to be successful (Kang & Kim, 2009).

Kang and Kim (2009) explained that in 4G wireless networks, user participation is required, but when users are resistant to participate, the viability of the network is jeopardized. Kim (2011) collected data from 1500 manufacturing employees regarding an enterprise resource planning (ERP) implementation. According to interviews, Kim (2011) suggested that episodes of user resistance of some capacity, overt (open & expressive) or covert (concealed or hidden) were observed in most employees participating in that study. Results of multiple studies conclude that there are multiple dimensions of switching costs, defined as one-time cost customers associate with the process of switching providers as causes of user resistance (Burnham, Frels, & Mahajan, 2003; Kim 2011).

Klaus and Blanton (2010) conducted a three-phase study, which consisted of an eight-person focus group, 22-person case study, and an 11-person semi-structured interview process from two companies. The results of the study found 12 determinants that disrupted the psychological contract between the employees and their organization and precipitated some level of user resistance. The determinants were classified into three categories: individual, system, and organizational. This study added to the body of knowledge by exploring the concepts associated with the development of user resistance in enterprise systems implementations.

Table 1. Summary of User Resistance studies

Study	Methodology	Sample	Constructs/Instruments	Findings
Hirschheim & Newman, 1998	Case Study, Literature Review		User Resistance, Information Systems Development,	Resistance is a complex phenomenon. Implementation of new systems will require organizational change both socially and politically.
Jiang et al., 2000	Empirical Survey	66 managers from a variety of organizations	Resistance, decision support systems, transaction processing systems, acceptance, effectiveness	Identified key reasons for user resistance in the development of decision support and transaction processing systems
Joshi, 2005	Case Study		User resistance and acceptance, Equity Implementation Model	Equity Implementation Model provides understanding of acceptance and resistance responses at various group levels during implementation

Table 1. Summary of User Resistance studies (continued)

Study	Methodology	Sample	Constructs/Instruments	Findings
Keen (1981)	Theoretical	Commentary	Leavitt (1965) Diamond (Task, Technology, People, Structure)	Informational systems development is political in nature as well as technical
Markus (1983)	Theoretical	Empirical/ Commentary	Kling's (1980) theories of resistance	Three theories of resistance: --System determined --People determined --Interactive
Kim, 2011	Empirical Survey	1500 manufacturing workers	User Resistance, switching cost, ERP implementation	Advancement of the theoretical understanding of enterprise systems implementation and user resistance to change.
Lapointe & Rivard 2005	Case Study		User resistance, IT & IS implementation, resistance behaviors	Within a given implementation of a system resistance has a variety of antecedents and manifestations that evolve and change in nature

Critical Value Factors

In order to counteract resistance to USAR robot use, there is an expectation that use will provide utility, sometimes referred to as perceived value. Value theory specifies what value is, what people value, and how value is applied in the context of human behavior (Ragowsky, Ahituv, & Newman, 1996; Ragow, Somers, & Adams, 2005). The construct of value has a deep history in the disciplines of anthropology, economics, political science, psychology, and multiple disciplines of sociology research (Keeney, 1999; Rafaeli & Raban, 2003). However, Ragowsky et al. (2005) noted that limited attention has been given to the user-perceived value aspect of the research discipline. Rokeach (1973) posits that within the socials sciences, the concept of value is a core concept more than any other concept. Thus, value is considered as a main independent variable in the study of behavior (Rokeach, 1973). Moreover, many researchers have criticized scholars for neglecting perceived value in their studies (Brown, 1976; Durgee, O'Connor, & Veryzer, 1996; Kahle & Kennedy, 1988).

Within the online learning space, Levy (2008) noted that very little attention has been given to online learners' perceived value. Levy's (2008) study explored the CVFs that institutions should review to reduce the dropout rate of online learners. Using a qualitative survey methodology, Levy (2008) developed a list of 51 activities valued by online learners. Ultimately, the list was narrowed to 45 activities and 600 students at a major university were invited to participate in the evaluation, which leveraged a self-developed 6-point Likert scale. This work resulted in the identification of CVFs that should reduce student frustration and potentially reduce the dropout rate of online courses. Additionally, improvement of the understanding of perceived cognitive value may assist researchers in their attempts to lower the dropout rate of online learning courses (Levy, 2008). By extension, this assessment can be extended to USAR in the context of allowing researchers to understand what operator's value by way of CVFs, which are necessary to save victims lives without risking their own life during a rescue operation.

Based on the Keeney (1992) value-thinking approach methodology, Dhillon, Bardacinco, and Hackney (2002) assessed the value of an individual's concern for privacy in the Internet commerce space. Like Levy (2008), Dhillon et al. (2002) identified eight fundamental CVFs for protecting privacy while online shopping. In their study, 92 interviews, 55 in the United States, and 37 in the United Kingdom, were conducted with users that had significant experience in Internet commerce activities such as shopping, information seeking, and research (Dhillon et al., 2002). The 40 minute interviews focused on what users viewed as important while shopping online. In this context, the value model facilitated thinking about new policies that will be beneficial to Internet commerce shoppers (Dhillon et al., 2002). Thusly, these CVFs build value propositions and confidence for individuals in the online shopping space. In a similar context, Sheng, Nah, and Siau (2005) used the Keeney's value-thinking concept to evaluate mobile technology and its strategic implications in the publishing industry.

Kohli and Devarag (2004) identified IT as a critical resource which creates organizational value. Porter and Millar (1985) further stated that IT has the capability to transform products, processes, companies, and industries. Sheng et al. (2005) interviewed 12 individuals, nine sales consultants, and three managers in 30 to 45 minute interviews regarding mobile technology used to support their job and company strategies. Six CVFs were identified and were found to correspond closely to the company strategies while also being sources of competitive vantage for the organization. Sheng et al. (2005) explained that their research is specifically focused on a publishing company, but the research can be applied to other organizations or areas that use mobile technology. In this case, USAR would benefit greatly from the application of mobile IT in the field in various disaster scenarios.

An additional study conducted by Nah, Siau, and Sheng (2005) surveyed users in the utility space to further show the value of mobile applications. Their study analyzed 425 employees of a utility companies Enterprise Resource Planning (ERP) implementation that was used to service 115,000 customers. Again, Keeney's (1992) approach is used and six CVFs are identified as most important. The results of their study provided a roadmap to help the company achieve its objective, implementation of mobile and wireless application, but from a research perspective, their study highlighted concerns regarding accessibility, real-time access and updates, as well as integration with the existing system, which needed to be addressed to provide additional value for the mobile application implementation.

One year prior, Siau, Sheng, and Nah (2004) completed a study associated with mobile commerce and the value-focused thinking approach, which additionally increased the body of knowledge by identifying concerns of customers in the mobile commerce space. In their study, 39 participants with at least two years of e-commerce experience were interviewed in one-shour blocks to identify six CVFs that provide value in the mobile e-commerce space. The results of their study showed that customers (or users) are not concerned with the creators of m-commerce systems; customers just want the systems to work (Siau et al., 2004). Additionally, their research provided an initial conceptual model, which could guide the research of future studies in the m-commerce space. Given this information, it can be concluded that people place value on certain things and it is up to technology implementers to discover what these values, or critical value factors are and how to use them to gain user acceptance. CVFs for USAR robots include human systems interaction, system communications, system mobility, and system sensing (Messina et al., 2005).

Dhillon and Torkzadeh (2006) used value-based thinking on a broader perspective to determine the value associated with information security. Based on in-depth interviews with 103 managers with at least five years of experience, Dhillon and Torkazadeh (2006) identified 16 CVFs which were validated by seven security panel experts. The results of their study revealed that security organizations need to make considerations beyond technical as well as adopt organizational principles and values. Additionally, Levy et al. (2009) revealed that very little attention has be given to user-perceived value in the context of system effectiveness. This observation by Levy et al. (2009) is supported by numerous scholars that acknowledge the challenges in IS research preventing measurement of IS effectiveness (Arnold, 1995; DeLone & McLean 1992; Doll & Torkzadeh, 1988; Ives, Olson & Baroudi, 1983; Kim, 1989). Grover, Seung, and Segars (1996) surmised that IS effectiveness depends on the unit of measure, whether it is organizational or individual in perspective. The focus of this research is on an individual perspective as the research attempts to ascertain which CVFs are important to USAR workers during disaster scenarios.

The literature provides evidence for conflicting views regarding user-perceived value. For example, work associated with evaluating levels of user satisfaction is focused on attitudes toward IS (Doll & Torkzadeh, 1998; 1991; Ives et al. 1983; Torkzadeh & Doll, 1991), primarily because research showed that very little information regarding understanding user satisfaction was gleaned from user-perceived value associated with system characteristics (Ives et al., 1983). However, there is disagreement in the literature based on research by Etezadi-Amoli and Farhoomand (1991), which reveal that a deeper understanding is gleaned from measuring user-perceived value regarding IS effectiveness. Bailey and Pearson (1983) recognized that user-perceived value was necessary to evaluate user satisfaction and user-perceived IS effectiveness from a system characteristics level. This research will focused on CVFs which present themselves through measurements of user satisfaction, user attitudes toward the systems, and overall effectiveness of the system from a user perspective.

To effectively evaluate the value provided to USAR workers, a systematic measurement criteria needs to be applied to the evaluation. In the Bokhari (2005) meta-analysis, it was shown that system usage and user satisfaction are widely used as surrogate measures for IS success. It should be noted that Bokhari also acknowledged that the measurement of a system and its “success” is a complex task. According to Delone and McLean (1992), IS success is a multidimensional construct consisting of two surrogate measures, system usage (Snitkin & King, 1986; Swanson, 1974) and user satisfaction (Bailey & Pearson, 1983; Baroudi & Orlikowski, 1988; Ives et al., 1983). The review of 180 studies led to seminal work by Delone and McLean (1992) providing numerous IS success measures in focus areas of system quality, information quality, system usage, user satisfaction, individual impact, and organization impact.

The focus of this research is related to systems quality in the context of human systems interaction (IS interface, availability, & response time); information quality in the context of system communication (information characteristics in terms of accuracy, timeliness, reliability, & meaningfulness); system usage in the context of system mobility (accuracy, reliability, & response time), and system usage in the context of system sensing (reliability, accuracy, & response time). According to Delone and McLean (1992), "the amount of use can affect the degree of user satisfaction – positively or negatively – as well as the reverse being true" (p. 83). Delone (1988) also noted that the time of use is not associated with system success. On the concepts of system use and satisfaction, there are arguments within the literature.

Conrath and Mignen (1990) argued that a positive attitude leads to more usage, but their results stated the opposite in that usage has more impact on satisfaction than the reverse. Udo (1992) argued that more system usage leads to less effectiveness and, therefore, less user satisfaction. Lee, Kim, and Lee (1995) claimed that system use leads to satisfaction and is positively correlated as do Torkzadeh and Dwyer (1994), who found that the effect of system usage regarding satisfaction was slightly greater than the reverse. Thus, the contradictions in the research suggest that more research is required to identify CVFs that effect value.

Messinal et al. (2005) provided an initial set of requirements associated with USAR robot roles and tasks generated from three workshops held at the National Institute of Science and Technology (NIST) from November 2004 to February 2005. These requirements were derived by surveying experts from 20 Federal Emergency Management Agency (FEMA) tasks forces in conjunction with the National Guard. Messina et al. (2005) identified 10 CVFs associated with USAR robots. Of those 10 CVFs, this research is focused on four CVFs which are believed to provide the greatest value for USAR workers during disaster situations.

According to Human-Robot Interaction (HRI), USAR is one of the highest profile research areas in the United States. Additionally, due to its importance, USAR has been classified as a HRI challenge problem. This means that efforts are underway to provide test areas, performance measures, and standards for the discipline (Goodrich, Olsen, Crandall, & Palmer, 2001; Krotkov, Simmons, Cozman, & Koenig, 1996; Murphy, Casper, Micire, & Hyams, 2000). For an effort deemed so important, an exhaustive literature search has yielded very little literature associated with CVFs in the USAR space. From the initial Messina et al. (2005) report, very little research has been conducted with CVFs for USAR rescue workers. Cooper and Goodrich (2006) presented an interface to support intuitive UAV control to save lives by integrating multiple interface components into a single model designed to support perception and understanding while avoiding information overload. Scholtz, Theofanos, and Antonishek (2006) acknowledged that at the completion of their study there were no metrics identified for HRI. Kadous, Sheh, and Sammut (2006) explained that if non-autonomous robots are the norm, human system interaction will be integral for any mobile robot system; this is especially the case for USAR. Kadous et al. (2006) also stated that the unfamiliarity of an environment coupled with unreliable communications and the addition of sensors can prove challenging for a human operator. Kadous et al. (2006) also noted that USAR robots must address three sub-problems:

1. Mobility and situational awareness – Traverse an area with stairs, ramps and rubble without hurting victims, causing secondary collapses, or destroying the robot.
2. Victim identification - Detect victims and provide details of their body shape, heat signature, and establish if they are moving.
3. Mapping – Produce maps that show the location of victims and landmarks that aid rescue workers.

As a result of their study, Kadous et al. (2006) concluded their attempt to provide a robust human-robot interface in a simulated environment was successful since operators could quickly learn the interface, effectively control the robot, efficiently identify victims and landmarks, as well as do so with minimal operator errors. De Greef, Hendriks, Neerincx, and Kruijff-Korbayova (2015) revealed that robots are not viewed favorably in mixed human-robot USAR missions. De Greef et al. (2015) stated that advances in artificial intelligence and design will hopefully change this view. Focus groups from the de greef et al. (2015) study showed that there is a possible requirement for robots to present themselves in a social manner (speech, vision, or touch) during USAR. While this research is not focused on social queues, there is a chance that an expert panel may identify one of these social queues as a CVF. Thus, more research is required to identify CVFs associated with USAR robots.

Human Systems Interaction (HSI)

HSI is the first critical value factor for USAR robots. This concept pertains to the human interaction and operator(s) control of the robot (Messina & Jacoff, 2006). It is critical that there is flawless human-robot interaction when robots go into situations where humans cannot follow.

System Communications (SYSCOMM)

SYSCOMM is the second critical value factor. This CVF is somewhat related to the HSI CVF since this is the primary medium for contact between robot and operator. However, SYSCOMM is different as pertains to the support for transmission of information to and from the robot. Examples include commands for motion or control of payload, sensors, vision, as well as underlying support for transmission of sensor and other data streams back to operator (Messina & Jacoff, 2006).

System Mobility (SYSMOB)

The third critical value factor is SYSMOB. This CVF deals with the ability of the robot to move over various terrains. The ability of the robot to negotiate and move around the environment is a key CVF as time is always a factor in USAR (Messina & Jacoff, 2006).

System Sensing (SYSSENS)

The last critical value factor is SYSSENS, which is described as the hardware and supporting software that allow the operator to receive input from the robot while searching for victims or navigating a structure (Messina & Jacoff, 2006).

Table 2. Summary of Value studies

Study	Methodology	Sample	Constructs/Instruments	Findings
DeLone & McLean (1992).	Theoretical	100 Studies	Literature Review	There are many IS success measures falling into six categories that are interrelated and interdependent
Doll & Torkzadeh (1988)	Empirical Survey	618 end users	End-user computing satisfaction/content, accuracy, format, ease of use, timeliness	Progress toward the development of a standard measure of end-user satisfaction
Ives, Olson & Baroudi, (1983)	Theoretical	22 studies	Literature Review	Lack of rigor in prior research limits the understanding of the nature of user involvement in computer-based information systems
Etezadi-Amoli & Farhoomand, (1991)	Analysis Review	1 study	End user computing / content, accuracy, format, ease of use, timeliness	New results analysis of the Doll and Torkzadeh study in an attempt to remove ambiguity regarding content items.

Table 2

Summary of Value studies (continued)

Study	Methodology	Sample	Constructs/Instruments	Findings
Bailey & Pearson, (1983)	Theoretical / Pilot test	32 respondents	Computer user satisfaction / accuracy, reliability, timeliness, relevance, confidence in the system	Definition of computer user satisfaction was developed. Translation of the definition in to a measurement instrument

Self-Efficacy

During a large part of the 1970's and 1980's, Bandura spearheaded the body of research on the topic of self-efficacy. Self-Efficacy purports that if individuals believe they are competent in an activity, they will then be more likely to participate in that activity. Bandura developed this theory out of his disagreement with the philosophy of behaviorism (Redmond, 2009). Bandura developed self-efficacy theory from a larger foundational model known as social learning theory (SLT), which is now referred to as social cognitive theory (SCT). SCT suggests that individuals learn from the observations of others while under the influence of environmental, behavioral, and cognitive factors.

One of Bandura (1977)'s seminal works concerning self-efficacy dealt with the development of an integrative theoretical framework explaining and predicting psychological changes derived from different modes of treatment. During this experiment, he separated participants who suffered from a distinct psychological phobia into two groups, one a modelling treatment group that was subjected to an intervening condition or treatment, while the other group was situated in a controlled condition without any intervening treatment. The severe phobics in the modelling treatment group were exposed to conditions designed to cause differential levels of efficacy expectations during a therapeutic task, thus creating a cause and effect relationship. The phobics in the second group did not receive any intervening treatment while performing the same therapeutic task. The microanalyses findings revealed that this theoretical framework accurately predicted the magnitude and generality of behavioral change for efficacy expectations produced both vicariously and willfully. Furthermore, Bandura (1977)'s predictive model was found to be extremely useful in projecting successes at the level of individual tasks both during and after treatment. Conclusions drawn from his findings supported the hypothesized relationships between perceived self-efficacy and behavioral changes.

In a later work, Bandura (1989) explored the concept of human agency in social cognitive theory (SCT), an antecedent of self-efficacy theory. Human agency is generally categorized in any of the following three ways: autonomous agency, mechanical agency, or emergent interactive agency. Human agency proposes that humans are purely independent agents of their own actions (Bandura, 1989). More precisely, it is "people's beliefs about their capabilities to exercise control over events that affect their lives" (p 1175). Bandura (1989) weaved discussion concerning self-efficacy in and out of the discussion in this research; however, the self-efficacy discussion is sparse and brief. Bandura (1989) suggested that self-efficacy beliefs function as a critical set of closely related determinants of human motivation, affect, and action. Bandura concluded that self-efficacy beliefs affect thought patterns that may ultimately result in either self-aiding or self-hindering actions.

Compeau and Higgins (1995) continued or built upon much of the earlier research dealing with self-efficacy. Their more recent contributions to this body of research is plentiful and noteworthy. Compeau and Higgins (1995) resulted in highly acclaimed research concerned with the development of a preliminary test and new measure for self-efficacy. Their motivation for this research stemmed from the notion that a reliable and valid measure of self-efficacy was required that would make beneficial assessments possible within organizational settings. Compeau and Higgins (1995) targeted knowledge workers as potential subjects whose work required them to deal with large amounts of information. They ultimately surveyed managers and professionals from within Canadian businesses to develop and validate their measurement instrument. The development of the measures was based on previous SCT literature and research by (Burkhardt & Brass, 1990; Gist, et al., 1989; Hill, et al., 1986; 1987; Webster & Martocchio, 1992; 1993).

Compeau and Higgins (1995) review of literature revealed several pre-existing measures for self-efficacy, but their review also indicated a need for additional or improved measures to be developed. An SCT-based model was devised that proposed a total of 14 hypotheses centered upon individuals' self-beliefs (efficacy) regarding their computer usage. The findings from Compeau and Higgins (1995) revealed that the influence of individual's expectations regarding their computer usage was significantly affected by their self-efficacy. It was concluded from the findings of their study that it was important to understand self-efficacy and how it contributes to the implementation of systems in organizational settings.

Peterson and Arnn (2005), who studied self-efficacy in the context of human performance, published recent research that explored the reasoning behind what causes a human to perform, and then proposed the additional component of self-efficacy within their human performance framework. Peterson and Arnn (2005) built on the work of Gilbert (1978), and Ryle (1949) who defined human performance as “behavior that changes the employee’s environment in ways that are respected and prized; that are achievements or accomplishments by the organization” (p. 5). Human performance is based on a model by Campbell and Pritchard (1976). Peterson and Arnn (2005) suggested that due to an expansion of the research field, current human performance models should incorporate the concept of self-efficacy within them. Peterson and Arnn (2005) provided lengthy discussion on self-efficacy to justify its inclusion within their proposed model.

A thorough reading of this published work did not indicate that the model was tested during this research. However, Peterson and Arnn (2005) suggested that consultants, technologists, managers, designers, trainers, and coaches would be strongly recommended to include self-efficacy in performance evaluations within organizational settings. This is because employees with low self-efficacy typically blame their workplace failures on their inability to perform job-related tasks (Peterson & Arnn, 2005). The principal researchers offered the conclusion that self-efficacy is a foundation for human actions. Peterson and Arnn (2005) also concluded that further research into self-efficacy could provide measures and resources to definitively reveal performance gaps that could enhance performance in the workplace.

Three remaining studies in this discussion on self-efficacy appear to be closely related as they all address self-efficacy and online privacy: (LaRose, Rifon, & Wirth, 2007; Ng, Kankanhalli, & Xu, 2009; Milne, Labrecque, & Cromer, 2009). While privacy is not a focus of this research, it should be noted that the literature does consider privacy in the context of HSI for USAR. Murphy (2004) revealed a concern about wireless unencrypted communications is the form of video that might be intercepted by a news agency, violating a survivor's privacy.

LaRose, Rifon, and Wirth (2007) built upon protection motivation theory (PMT) to examine factors affecting protective online behaviors of Internet users. Factors affecting safe online behaviors were examined. A safe intervention scheme was developed and administered to a cross-sectional sample of Internet users. Additionally, new variables identified as personal responsibility and self-efficacy were tested through an experimental manipulation. This work was grounded in health communication that has recently been applied to precautionary online safety behaviors (LaRose & Rifon, 2006; Lee, LaRose, & Rifon, 2007; Youn, 2005). Comparative behaviors between protective security practices and preventative healthcare practices can be observed, for example, eating healthy to avoid or reduce obesity, compared with routinely backing up files, or performing anti-virus scans to discourage risky, damaging computer behavior (Ng, Kankanhalli, & Xu, 2009). Further examples of risky online behavior would include reading privacy policies before supplying personal information, downloading software before reading the license agreement, or opening unknown, suspicious email, including any attachments.

LaRose, Rifon, and Wirth (2007) targeted adult Internet users as the population of interest in this study. A total of 2000 surveys were distributed by mail and online in which 1,891 respondents comprised a usable sample. Out of the 1,891 respondents, 275 returned the mailed surveys and 166 respondents completed the online survey for a final sample of 441 respondents. Four hypotheses were generated in which the first two were confirmed, the third hypothesis was not supported at all, and the fourth hypothesis was only partially supported by the data analysis.

During previous research, LaRose and Rifon (2006) conceived a model comprised of elements of PMT within the framework of SCT, thus incorporating self-efficacy into their conceived online protection framework. LaRose, Rifon, and Wirth (2007) discovered that coping self-efficacy was found to be a powerful variable in findings they discovered from a study by Lee et al. (2007). However, upon a deeper review of the literature, the lead investigators also found research revealing that self-efficacy was not significantly associated with an effective method of healthcare protection intervention (Dinoff & Kowalski, 1999; Stolberg, 2006).

LaRose et al. (2007) reported on limitations of this study revealing that the sample was drawn from only one state resulting in a low response rate that could potentially call validity of the study into question. This could also have detrimental effect on the robustness of the findings. LaRose et al. (2007) summarily found that showing people how to protect themselves online and merely telling them how to protect themselves online had two very different outcomes. Showing the participants how to protect themselves contributed positively to their self-efficacy, thus, yielding a higher level of participation and rate of success. However, they warned that self-efficacy and personal online safety responsibility manipulations have complex interactions that should only be intertwined sparingly and cautiously.

A similar study into users' computer security behavior was performed by Ng, Kankanhalli, and Xu (2009). As in LaRose et al. (2007), this study by Ng et al. (2009) was also grounded in a health belief model existing in healthcare literature to study users' computer security behavior. The motivation for this research was based on observations that relatively few research studies existed concerning computer user security behavior and how behavior can be modified to encourage security countermeasures (Ng et al., 2009). They also referred to an expectancy-value approach upon which much of preventive healthcare behavior is based upon. As expectancy was described, it closely mirrors self-efficacy as Ng et al. (2009) defined it as “beliefs about how well a person can perform a task or activity” (p. 817). They also define value as “the incentives or reasons for performing that task or activity” (p. 817).

A model was devised and a sample population of 134 organizational employees were used to validate it. A total of 10 constructs and seven hypotheses were developed and examined, one of which being self-efficacy. Ng et al (2009) informed that while most studies would use behavioral intention as the dependent variable, they opted to use the construct of self-reported actual behavior. Their model was quantitatively tested using survey methodology. Their results revealed that the constructs of perceived susceptibility, perceived benefits, and self-efficacy were determinants of email related security behavior. Their moderating variable of perceived severity affected perceived benefits, general security orientation, cues to action, and self-efficacy on security behavior. Limitations of their study that were discussed warned that only one security practice (email usage) was measured that limited generalizability of the results to other computer security practices. Sample size was cited as another limitation as it was stated that future research would benefit from a much larger sample size. Perhaps the main implication of their study was its narrowing of the gap towards our understanding of users’ computer security behavior in organizational settings.

Milne, Labrecque, and Cromer (2009) delved into protection motivation theory (PMT) and social cognitive theory (SCT) to investigate the degree to which the level of perceived threat and likelihood of threat, along with online self-efficacy, affect online behaviors. More specifically, their research examined the extent to which a consumer's self-efficacy directly affects protection choices and if and how it may moderate the relationship between threat and protection decisions.

A conceptual model was proposed with the development of eight hypotheses to measure how perceived threat, likelihood of threat, and self-efficacy directly affect adaptive and maladaptive behaviors, as well as risky and protective online actions. A national online survey instrument was developed and 449 respondents returned them. Data analysis consisted of Coefficient alpha for agree/disagree items and Spearman Brown reliability for the summated scales. Convergent and discriminant validity was established for some of the variables with standard Confirmatory Factor Analysis procedures. The results of Milne, Labrecque, and Cromer (2009) showed that both self-efficacy and demographic factors such as age have a differential impact on the type of behaviors taken online.

Table 3. Summary of CSE studies

Study	Methodology	Sample	Constructs/Instruments	Findings
Beas & Salannova, 2006	Empirical Survey	496 Information Technology workers	Self-Efficacy, training, attitude, well being	Self-Efficacy has a positive relationship to psychological well-being; Regarding training, attitudes are a moderator toward self-efficacy.
Burkhardt & Brass, 1990	Empirical Survey	81 federal employees	CSE, Age, Education, Attitude, Early Adoption	CSE significantly correlated to age, early adoption, and training time.
Chou, 2001	Empirical Survey	101 high school students	CSE, computer anxiety, training method, gender, performance	Modelled/evaluated the effects of training methods, gender, showed that computer anxiety influenced CSE.
Compeau & Higgins, 1995	Empirical Survey	1020 knowledge workers	Encouragement and use from others, support, CSE, Expectations, Usage	Development of a 10-item measurement for CSE.
Gist et al., 1989	Empirical Survey	108 university managers and administrators	CSE, Performance, Satisfaction, work style, experience, training	CSE was shown to increase with training.
Igbaria & Iivari, 1995	Empirical Survey	450 Business users	CSE, Perceived Usefulness, Perceived Ease of Use, Anxiety, Organizational support, system usage, experience	CSE was shown to have a direct effect on system usage as well as a negative relation to anxiety.

Table 3. Summary of CSE studies (continued)

Study	Methodology	Sample	Constructs/Instruments	Findings
Marakas et al., 1998	Literature Review with Analysis		CSE	Theoretical model developed for CSE which reinforced the multi-facets of CSE.
Torkzadeh & Van Dyke, 2001	Empirical Survey	277 MIS undergraduate students	Self-Efficacy of Internet	17-point survey developed associated with Internet Self-Efficacy.
Wilfong, 2006	Empirical Survey	242 College students	Computer Anxiety, Anger, and Experience, CSE	CSE greatly impacts computer anxiety and anger; CSE found to be a strong predictor of computer anxiety.

Summary

Kim and Kankanhalli (2009) conducted a study that investigated resistance to a new information system within an organizational setting. Status quo issues, or bias experienced on the part of users who disliked change and therefore resisted new technology was of interest. While user resistance is typically not framed as good or bad (Ferneley & Sobreperez, 2006; Lapointe & Rivard, 2005), resistance is not well received or valued in most organizational environments (McGrath, 2006; Willmott, 1993). This introduces a common notion that user resistance must be mitigated for functional outcomes to be realized (Selander & Henfridsson, 2012).

While much attention has been given to user satisfaction, and user effectiveness in IS literature, minimal research focus has persisted on the constructs of IS success in the domain of USAR. Since USAR is classified as a challenge problem by the government, the lack of research may be attributed to technology as well as resistance of USAR workers to use the technology. Numerous instruments have been developed over time to measure IS success and end user effectiveness. Levy (2008) developed a measure to explore CVFs regarding online learners and their dropout rate. From the initial Messina et al. (2005) report, very little research has been conducted with CVFs for USAR rescue workers.

Compeau and Higgins (1995) review of literature revealed several pre-existing measures for self-efficacy, but their review also indicated a need for additional or improved measures to be developed. The findings from Compeau and Higgins (1995) revealed that the influence of individual's expectations regarding their computer usage was significantly affected by their self-efficacy. It was concluded from the findings of this study that it was important to understand self-efficacy and how it contributes to the implementation of systems in organizational settings. The contribution of this research to the field of IS will be realized the assessment of CVFs of USAR, which could lead to the reduction of user resistance from USAR workers when they are trying to rescue victims in disaster scenarios.

Chapter 3

Methodology

Introduction

The purpose of this mixed methods study was to examine the critical value factors (CVF) and the system characteristics that cause urban search and rescue (USAR) members to resist the use of robots. This study was significant given that USAR is a highly risky job requiring the investigation of disaster sites (Burke et al., 2004), in addition to robots having the potential for saving human lives as demonstrated in previous, limited use exercises. Research suggested that further use of more interactive robots would allow for widespread use (Bishop et al., 2005). The probability of adoption was a function of perceived usefulness and personal benefit to oneself or their organization (Ahituv et al., 1981). This research is significant because it expands knowledge on barriers to USAR robot adoption. The research is also significant because it advances current research in Information Management and increases the body of knowledge regarding IS users' behavior as it relates to CSE, CVFs, and RES.

This chapter presents the study's research design and rational, its methodology, a list of all pertinent study variable operationalization, a data analysis plan, a description of reliability and validity, an overview of all this study's ethical considerations, and the chapter's summary. This study used data collected from a research panel in combination with surveys acquired from anonymous first responders who had the potential to act as USAR members.

Research Design and Rationale

The dependent variable was identified by qualities that help determine the adoption of robots by USAR members, while the independent variable was identified as the act of adopting these robots by USAR members in the investigation of disaster sites. This mixed methods study used a correlative research design. The methodology was designed to measure the CVFs that were critical for the adoption of robots by USAR members. The correlative research design was appropriate when variables could not be limited sufficiently to create an experimental environment. It was particularly appropriate when a relationship needed to be determined between two or more variables using statistical data. The correlative research design was appropriate when variables could not be manipulated to determine a causal relationship. When a causal relationship could not be determined, the use of a validated survey tool was used to study relationships and the use of statistical analysis used to help determine statistically significant relationships between variables. This study followed the approach of Straub (1989) as depicted in the research method process (Figure

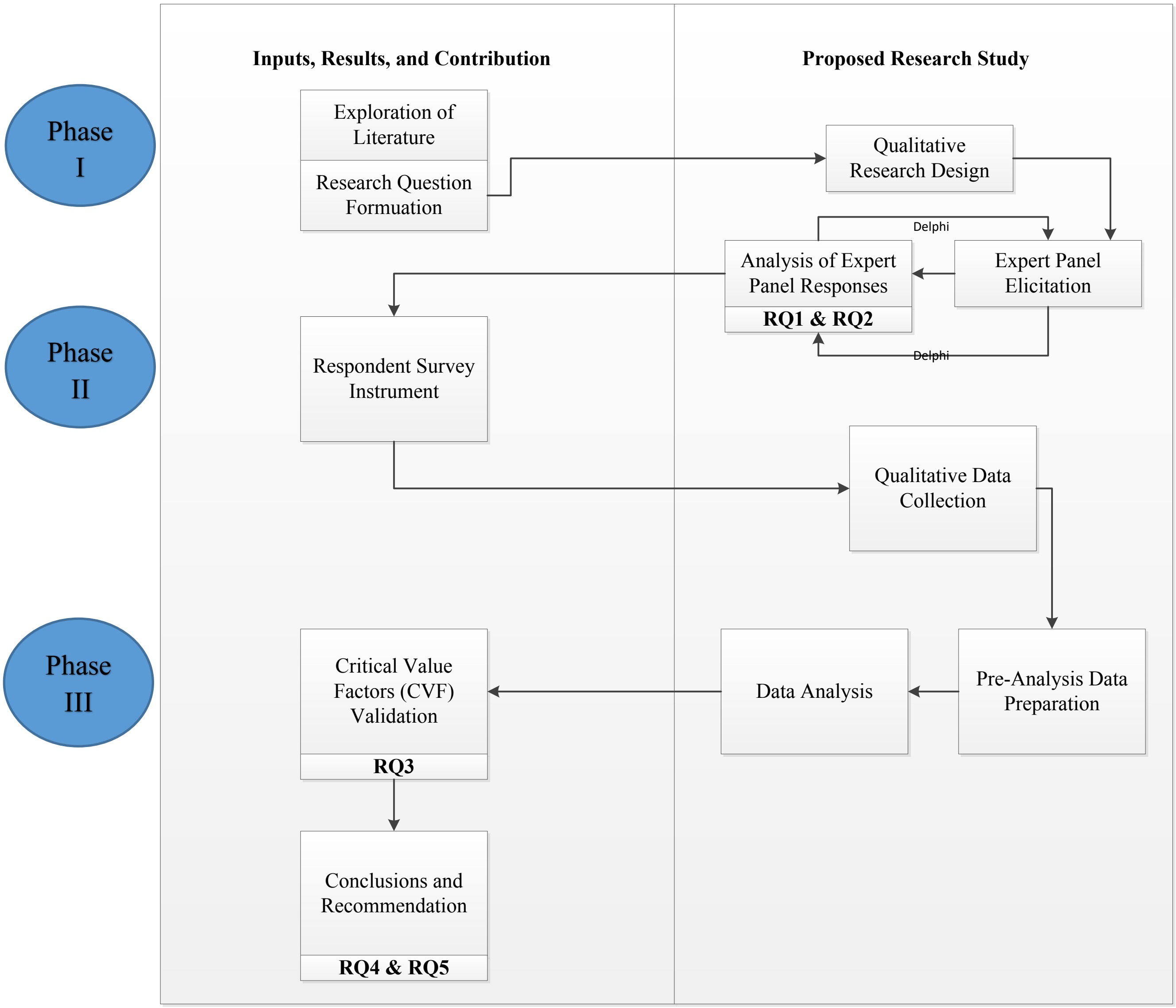

Figure 6. Research Method Process

Population

This study population consisted of 2,500 active USAR team members from the Houston Professional Fire Fighters Association (HPFFA), which is a subset of the 4,035 Houston fire fighters (HPFFA, City of Houston, 2016). This study population was limited to USAR members with search and rescue exposure.

Sample Size and Sampling Procedure

The sample population was recruited from 2,500 USAR team members from the HPFFA. The expected response rate was approximately 15% of the participants, thus, yielding approximately 300 responses. This study used a survey methodology to identify the USAR system characteristics and CVFs that team members find valuable during disaster events. The minimum sample size was calculated by assuming a confidence interval (CI) of 95% and margin of error (ME) of 5%; the minimum sample size for a population of 2,500 was approximately 250 respondents.

Data Collection Procedures

The qualitative phase of data collection used open-ended questionnaires distributed among an expert panel. The open-ended questionnaire allowed for a broad range of responses to questions regarding CVFs that helped determine the adoption of robots by USAR members. The quantitative phase of data collection occured using a validated survey tool which was administered to USAR members. This survey measured CVFs that may potentially determine the adoption of robots by USAR members. During both the qualitative and quantitative phase of data collection, demographic data for age and gender was also collected. Both phases of data collection sought to reflect the demographics of the larger population from which the sample was drawn.

Members of the panel responding to the open-ended questionnaire were identified at various schools and research facilities across the country and were contacted via email and phone to request their participation in the study. Following initial contact, those participants who were open to participating as part of the expert panel were provided email links by which they responded to the open-ended questionnaire. Responses were submitted online due to existing time and resource limitations. USAR members responding to the quantitative survey were solicited in similar fashion. USAR departments were contacted and requests for survey participation we made via the communications officer for the organization. The communications officer provided the respondent population with an initial request for participation via electronic newletter, a follow up posting was sent to closed social media groups requesting participation via links to the online survey, including all ethical information regarding the study's purpose, the use of the data, the ability for the participant to withdraw at any time, and data access.

Instrument Development

This study included a two-phased approach of qualitative and quantitative methods to collect important system characteristics and CVFs that contributed to USAR team members' resistance to use RES. The qualitative and quantitative methods added sufficient rigor to this study. Straub (1989) noted that research methodologists widely accept qualitative and quantitative methods to uncover information in research.

Expert Panel

This study adhered to Keeney's (1999) qualitative approach to address the first specific research question: What are the USAR robot system characteristics that are important for USAR team members when using specialized robots? Straub (1989) noted that literature reviews and expert panels lend themselves to content validity. To assess the qualitative methodology, a small focus group of 20-30 USAR experts who will be asked to answer an open-ended qualitative questionnaire to express the list of system characteristics that are important for USAR team member when using specialized robots. Appendix A contains common demographics questions for both the pilot study and the main study. As noted by Van Teijlingen and Hundley (2001), the pilot study sample was representative of the target study population inclusive of exclusion criteria. The open-ended qualitative questions are shown in Appendix A.

Upon completion of the expert panel, main data collection commenced using a quantitative survey instrument to collect the data and address RQ2, what are the CVFs of the USAR system characteristics. This survey instrument was created by leveraging the information from the phase one collection. The survey instrument addressed the question: What are the CVFs of the USAR system characteristics. Additionally, the initial quantitative survey instrument collected data to assess demographics to test for research questions three thru five and all hypotheses while ensuring that a representative population sample was collected. Mertler and Vannata (2010) suggested that once the data was collected, pre-analysis data screening be conducted according to standard research methods. Appendix A contains the quantitative survey.

Study Variable Operationalization

Computer Self-Efficacy (CSE). A judgment of one's capability to use a computer. CSE in the context of USAR robots research is defined as an individual's belief about their ability to use such robots to locate victims in a rubble pile (Compeau & Higgins, 1995). For the purposes of this study, CSE wAS measured using the validated survey tool as a means of self-assessment.

Critical Value Factors (CVFs). The factors of the system characteristics that individuals view as important to increase their perceived value (Levy, 2008). For the purposes of this study, CVFs was determined by using an expert panel and the study sample includes only USAR members.

Organization role. What role the USAR member plays during a search and rescue operation.

Resistance to USAR robot use. Opposition of a user to change associated with a new IS implementation (Kim & Kankanhalli, 2009), as measured by CVFs.

USAR live event. The participation of an USAR member in the search and rescue of individuals trapped during a disaster.

USAR experience. USAR experience is defined as the number of years that an individual has operated as a member of an USAR team.

For each study variable, Table 4 depicts data type, variable type, and data source. Age, gender, organizational role, USAR live event participation, and years' experience may be covariates and Pearson Product-moment correlation statistics will be used to test the assumption.

Table 4. Variables, Scales of Measurement, Variable Type, and Source

Variable	Data Type	Variable Type
Resistance to USAR Robot use (RES)	Interval	Dependent Variable
Critical Value Factors (CVF)	Interval	Independent Variable
Computer Self-Efficacy (CSE)	Interval	Independent Variable
Age (AGE)	Continuous	Covariate
Gender (GEN)	Dichotomous	Covariate
Organization role (ORG)	Categorical	Covariate
USAR live event (PLE)	Dichotomous	Covariate
USAR experience (EXP)	Continuous	Covariate

Pre-Analysis Data Screening

Pre-analysis data screening dealt with the process of detecting and handling irregularities or problems with collected data (Levy, 2006). To ensure consistency and accuracy of the data collected, pre-analysis data screening was conducted after data collection. Mertler and Vanatta (2010) noted that data must be checked for accuracy and consistency to ensure the validity of the results. Mertler and Vanatta (2010) also identified four reasons to conduct pre-analysis data screening: 1) to deal with missing data; 2) to deal with response set; 3) to deal with missing data; and 4) to deal with outliers or extreme cases.

Data Analysis Plan

This study was in line with methodology from Keeney (1999), using a mixed quantitative and qualitative approach to identify important system characteristics and CVFs that contribute to USAR team members' resistance to use RES. Responses collected from the online survey were be analyzed using Exploratory Factory Analysis (EFA) through Principal Component Analysis (PCA). Newsom (2005) noted that EFA is used to identify the factor structure of a measure and examine its internal reliability. There are three decision points associated with EFA: (a) the number of factors, (b) choose an extraction method; and (c) chose a rotation method. Mertler and Vannata (2010) identified various steps to PCA including the two methods for choosing the factors. Method one follows Kaiser's rule which states that only components with Eigenvalues greater than 1 should be retained. The second method uses graphics for determining the factors. Method two is called a scree test and involves a scree plot. The scree plot graphs the magnitude of each Eigenvalue plotted against the ordinal values. The numbers of factors retained and studied are the factors located on the bend of the scree plot. The study model was tested using Multiple Linear Regression (MLR). The model also analyzed the overall measures of CVF and CSE. It is important to identify the dependent

variable that will be used for prediction (Sprinthall, 1997). SPSS was used to calculate MLR statistics for RQ's 4-1 through 4-4 to examine the contribution of CVFs and CSE on USAR team members' RES after controlling for potential covariates.

Table 5. Statistics to Test Each Hypothesis (noted in null form)

Hypotheses	Study Variables	Statistic
H_o1: There will be no significant contribution of USAR team members' Critical Value Factors by their Resistance to use USAR Robots	CVF, RES	EFA-PCA
H_o2: There is no significant contribution by USAR team members' Computer Self-Efficacy to their Resistance to use USAR Robots	CSE, RES	EFA-PCA
Ho3: There is no significant contribution by the interaction effect between USAR team members' Critical Value Factors and Computer Self-Efficacy to their Resistance to use USAR Robots	CVF, CSE, RES	EFA-PCA
H_o4-1: USAR team members' Resistance to use USAR Robots is not significantly differ among their Critical Value Factors and Computer Self-Efficacy, when controlled for age	CVF, CSE, RES, age	ANCOVA
H_o4-2: USAR team members' Resistance to use USAR Robots is no significant difference among Critical Value Factors and Computer Self-Efficacy, when controlled for gender.	CVF, CSE, RES, gender	ANCOVA
H_o4-3: USAR team members' Resistance to use USAR Robots is not significantly different among Critical Value Factors and Computer Self-Efficacy, when controlled for prior participation in live USAR event.	CVF, CSE, RES, PLE	ANCOVA
H_o4-4: USAR team members' Resistance to use USAR Robots is not significantly different among Critical Value Factors and Computer Self-Efficacy, when controlled for their years of USAR work experience.	CVF, CSE, RES, EXP	ANCOVA
H_o4-5: USAR team members' Resistance to use USAR Robots is not significantly among between Critical Value Factors and Computer Self-Efficacy, when controlled for their organizational role	CVF, CSE, RES, ORG	ANCOVA

Reliability and Validity

Reliability. Documenting internal consistency within the research process is known as establishing reliability (Sekaran, 2003; Straub, 1989). Straub, Rai, and Klein

(2004) defined reliability as "the extent to which a variable or set of variables is consistent in what it is intended to measure" (p. 70). The most commonly used measure, Cronbach's Alpha, determines reliability of an instrument (Hair, Anderson, Tatham, & Black, 1984; Sekaran, 2003; Straub et al., 2004). Gefen, Straub, and Boudreau (2000) noted that the Cronbach Alpha scale measures on a range of .60 to 1.0 with .60 being the lowest limited of the measure, and 1.0 as a measure of almost complete reliability. There are, however, additional researchers such as Nunnally (1967) as well as Nunnally and Bernstein (1994) that suggested .70 should be the lowest limited deemed acceptable. Cronbach's alpha will be used to measure the reliability of survey instrument used in this study. Items identified as falling below .70 during this study will be reviewed and reworded or removed from the list.

Validity. "Validity is the degree to which an instrument measures what it purports to measure" (Lunenburg & Irby, 2008, p. 181). Straub (1989) noted that validation of a survey instrument is a crucial requirement in the realm of research. Throughout history IS research has suffered from the lack of validated instruments, thus providing doubt of the legitimacy of study results (Straub 1989; Straub et al., 2004). Straub et al. (2004) defined valid measures as measures that "represent the essence or content upon which the entity or construct is focused" (p. 5). Hair et al. (1984) suggested that validity is the measure of how accurately an instrument measures what it is supposed to measure. Internal validity however, is the level of confidence the researcher has on the causal effect of the constructs (Sekaran, 2003). Straub (1989) supported this notion by suggesting that internal validity refers to "whether the observed effects could have been caused by or correlated with a set of un-hypothesized and/or unmeasured variables (p. 151). This study minimized validity threats by using measures that were validated in prior research in addition to the use of an expert panel pilot study. This study was limited to a group of first responders from a single firefighters union in a specifc city and state within the United States. The HPFFA is a cross section of first responders and provided a representative generalized sample for this study.

Data Analysis

Mertler and Vannata (2010) noted that path analysis utilizes repeated multiple regression to identify whether a cause relationship exists between multiple variables. Analysis of covariance (ANCOVA) is used to factor out error that has been introduced by the covariate (Mertler & Vannata, 2010). This study followed methodology identified by Shaw (2009) to analyze RQ5 and hypotheses H4a – H4e to determine if there were any significant differences on CVFs, CSE, and RES based on age, gender, prior experience with USAR events, years of USAR experience, and organizational role.

Ethical Considerations

Permission from the governing body for Texas State Association of Fire Fighters was required before data collection from USAR team members could begin. Internet survey software was required to develop and deploy the survey instrument. Survey Monkey® was used for this purpose. Following data collection, Statistical Package for the Social Sciences® (SPSS) was used to analyze the data. Prior to participation in the survey, USAR members were provided details regarding the purpose of the study, who would handle the data, who would have access to the data, where and how long the data would stored, and how the data would be used. The USAR members were informed that all data collected would be kept private and used solely for the study, although the raw data itself will be retained for a period of seven years before destruction. Only the researchers are able to access the data, which will be kept on a secured drive in the cloud. Finally, all USAR members were informed that they were allowed to leave this study at any time without fear of consequence for their departure.

Summary

This study used a mixed methodology. The correlative research design was appropriate given the inability to manipulate variables to determine a cause and effect relationship, in addition to the need to determine the potential strength of relationship between multiple variables. This study aimed to identify any potential strong relationships between CFVs and the probability of USAR members to adopt robots during their operations. This study used descriptive statistics and statistical analyses to determine relationships, describe the findings, and test the hypotheses.

Chapter 4

Results

Overview

This chapter provides the detailed results of the investigation. The results of this research are reported in the order in which the study was conducted. The chapter begins with the phase one qualitative research results, which included a literature review followed by the design, development, and admistration of an open-ended survey questionnaire delivered to an expert panel. This qualitative phase concluded with data collection and analysis which was used to identify the items used in the phase two quantitative stage of the research.

Phase two of the study began with the completion and distribution of the seven point likert scale survey instrument followed by quantitative data collection, pre-analysis data screening, and the identification of the CVFs for system characteristics and CSE using principal component analysis (PCA). Phase two also provides the results of tests for instrument validity and reliability in addition to the measurement of the impact of the CVFs and CSE on RES.

Phase three included testing of the factors retained on the bend of the scree plot. The study model was tested using multivariate linear regression (MLR). In this phase of of the study, the contribution of CVFs and CSE on USAR team members' RES were tested after controlling for potential covariates.

Qualitative Phase (Phase I)

This study utilized a mixed methods approach similar to the work of Keeney (1999), using both qualitive and quantitative research methods. In the qualitative phase, an expert panel of 20-25 USAR experts we asked for their opinion via open-ended survey, to identify the characteristics that they believed were important for USAR team members when using specialized robots. An initial list of 26 system characteristics were identified from literature (Appendix C) and distributed to the expert panel. The system characteristics spanned four categories, HSI, SYSCOMM, SYSMOB, and SYSSENS The results from the expert panel were then analyzed and added to the initial list of system characteristics. Using Keeney's (1999) approach, characteristics with similar meaning were consolidated into a single grouping. For example, 'interactive user interface' and 'HUD user interface' were merged and added to the HSI category as a single user interface item. Items that did not appear to be relevant to systems characteristics were reviewed and cross referenced via literature review and ultimately added to or discounted from the original list. At the end of the analysis, six HSI system characteristics were added, three SYSCOMM system characteristics were added, four SYSMOB system characteristics were added, and 15 SYSSENS system characteristics were added to the list based on the literature review and expert panel responses. The final list of system characteristics can be seen in table 6.

Table 6. System Characteristics of USAR from Phase I: Qualitative Method

No.	Proposed Factors	System Characteristics
1	HSI	Remote Information Sharing
2		Operator Disengagement
3		Probability of Detection
4		Self Extraction
5		Lighting Conditions
6		Mobility
7	SYSCOMM	Beyond Line of Sight Communications
8		Security
9		Line of Sight Communications
10	SYSMOB	Area Coverage
11		Sustained Speed
12		Tumble Recovery
13		**Climbing Ability+**
14	SYSSENS	Camera Pan
15		Camera Tilt
16		Camera Field of View
17		Real Time Video
18		Seismic Detection
19		Thermal Imaging
20		Hazard Detection
21		2-way audio
22		Spatial Modeling
23		Waypoint Annotation
24		Victim Indicators
25		System Health
26		Void Detection
27		Range Finder
28		**Structural Senors+**

+ items added from expert panel

Demographic Analysis

After completion of the pre-analysis data screening of 266 responses, it was determined that 233 or 87% were completed by male and 33 or 12.40% were completed by females. The authors of the United States Fire Department Profile of 2013, explained that approximately 354,600 individuals are career firefighters and of this number, only 11,100 are female or 3.7% (Haynes & Stein, 2014). Analysis of the ages of respondents indicated that 71 or 26.70% were between the age of 18 to 24, 104 or 39.10% were 25 to 31 years of age, 57 or 21.40% were between the ages of 32 to 45, 30 respondents or 11.30% were between the ages of 45 to 54, 4 respondents or 1.5% of the population were 55 to 64 years of age, and zero respondents were over the age of 65. 86 respondents had zero experience in USAR events which was 32.30% of the population, 111 respondents or 41.70% had participated in one to six USAR events, 45 respondents or 16.90% had participated in seven to eleven USAR events, 17 respondents or 6.40% had participated in 12 to 16 USAR events and 3 respondents or 1.10% had participated in more than 17 USAR events, while only four respondents had participated in more than 25 USAR events. Within the population, it was determined that 111 respondents or 45.10% had one to six years of experience working as a first responder, 71 respondents or 26.70% had six to ten years of first responder experience, while 37 respondents or 13.90% had 11 to 16 years of first responder experience, 14 respondents or 5.3% or respondents had 26 to 30 years of first responder experience, four respondents or 1.5% had 31 to 35 years of first responder experience, and one respondent or 0.40% had greater than 36 years of experience. Finally, with respect to organizational role, the data showed that six respondents or 2.3% held the role of captain, 43 respondents or 16.20% held the role of

EMT firefighter, 13 respondents or 4.90% held the role of engineer operator, 186 respondents or 69.90% respondents held the role of firefighter, five respondents or 1.90% held the role of Lieutenant, 13 respondents or 4.90% held the role of paramedic firefighter, and zero respondents held the role of station chief. Table 7 provides a tabular view of the data. The data clearly shows a simple correlation between age, years of experience, number of USAR events, and Organizational role. That correlation suggests that the grater the number of years of experience, the more USAR events an individual will have participated; thus, the potential exists for an opportunity for a higher organizational role exists.

Exploratory Factor Analysis via Principal Component Analysis

Quantitative data analysis. In phase II, the study used EFA techniques to uncover the CVFs of USAR. The statistical package for the social sciences (SPSS) software was used to calculate the relationships between all measurement items, which were then matched to the USAR construct categories of location mapping, visual identification, survivor surveillance, system awareness, secure connectivity, search mobility, and operator robot teaming. Factorial validity assessed whether the measurement items correlated to the theoretically anticipated CVFs for USAR operations. The PCA extraction method was used to provide variances of underlying factors (Mertler & Vanatta, 2001). The perceived CVFs of USAR were identified by employing EFA via PCA using the Varimax rotation. PCA was used to extract as many factors as derived by the data. No additional factors emerged from the analysis.

Table 7. Descriptive Statistics of Population (N=266)

Item	Frequency	Percentage (%)
Gender		
Male	233	87.60%
Female	33	12.40%
Age		
18 to 24	71	26.70%
25 to 31	104	39.10%
32 to 45	57	21.40%
45 to 54	30	11.30%
55 to 64	4	1.50%
Over 65	0	0.00%
USAR Event Participation		
None	86	32.30%
1 to 6	111	41.70%
7 to 11	45	16.90%
12 to 16	17	6.40%
17 to 25	3	1.10%
Over 25	4	1.50%
Years as First Responder		
0 to 5	120	45.10%
6 to 10	71	26.70%
11 to 16	37	13.90%
17 to 25	19	7.10%
26 to 30	14	5.30%
31 to 35	4	1.50%
36 or More	1	0.40%
Organizational Role		
Captain	6	2.30%
EMT Firefighter	43	16.20%
Engineer Operator	13	4.90%
Firefighter	186	69.90%
Lieutenant	5	1.90%
Paramedic Firefighter	13	4.90%
Station Chief	0	0.00%

USAR Factor Analysis

The literature review revealed four categories of USAR which contained system characteristics that were listed as potential CVFs of USAR. At the conclusion of the EFA via PCA using the Varimax rotation with the Kaiser criteria applied, only factors with eigenvalues greater than one would be considered for deletion. Based on the Kaiser criterion, the results of the PCA factor analysis suggested that seven factors with a cumulative variance of 61.936% should be retained.

The results of the scree plot (figure 6) further supported the findings of the PCA factor analysis. Examination of the graph indicated that there were seven points above the bend of the graph. The number of points above the bed is representative of the factors that should be retained. Before concluding the PCA analysis, an evaluation of forced factors of four, five, and six were considered in the search for an optimal number of factors. Ultimately, based on the results provided by both the Kaiser criterion and the scree test, it was concluded that the appropriate number of CVF factors for extraction was seven.

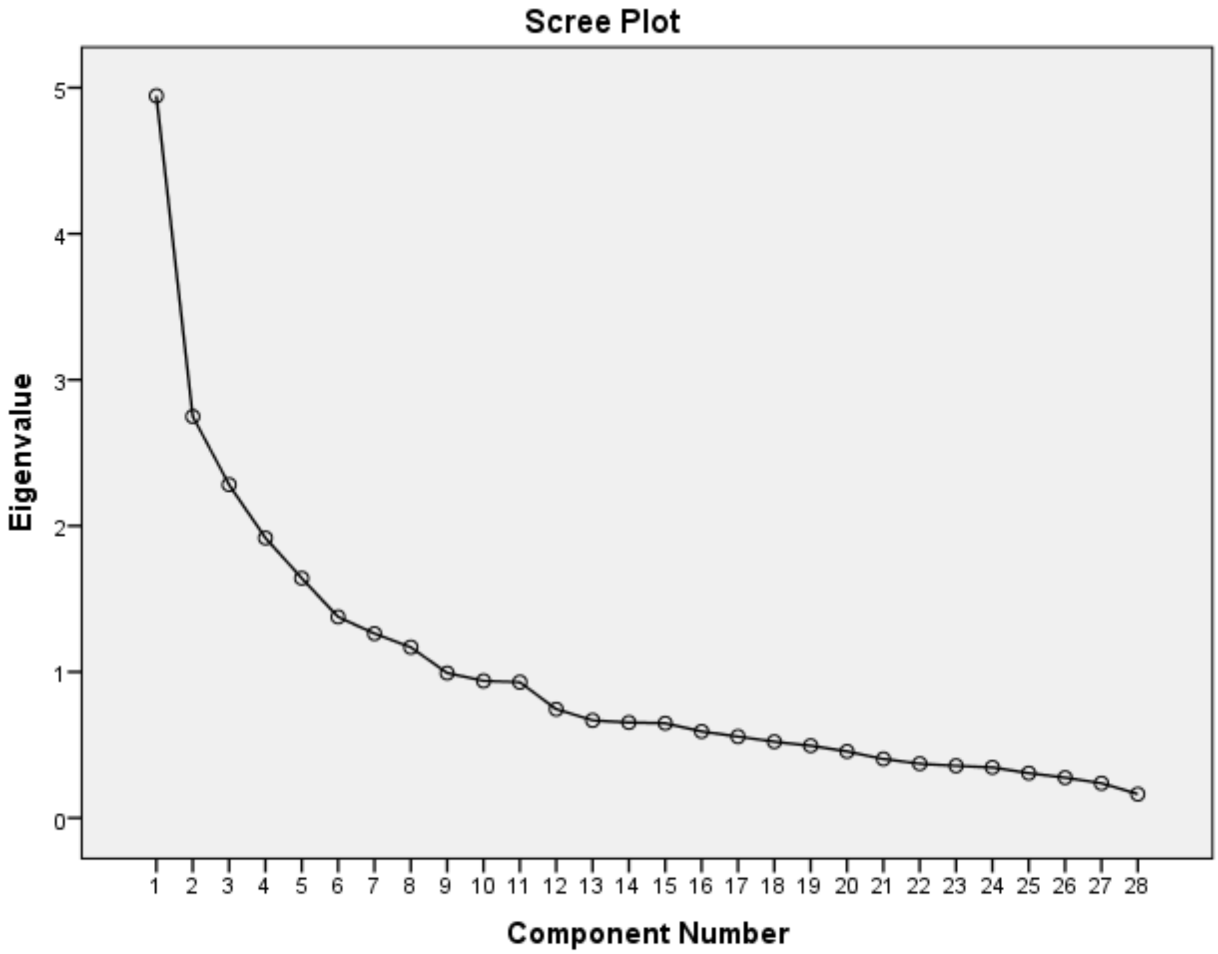

Figure 7. Scree plot for CVFs of USAR

CVF Reliability Analysis. Using the factor loadings, each survey item was scrutinized for low loading (< 0.4) or for medium to high loadings (~ 0.4 to 0.6) on more than any single factor. The results of this analysis indicated that none of the items were required to be deleted. The final results consisted of all 28 items from phases I and II. Based on the Mahalanobis distance analysis, CaseID 262 was removed from the PCA analysis and resulted in a N of 265 results. Results of the PCA analysis revealed that certain characteristics contained in the groupings of the phase I study (HSI, SYSMOB, SYSCOMM, and SYSSENS) should be regrouped into seven CVF categories more representative of their factor loadings.

The Cronbach Alpha reliability analysis produced results which suggested some level of reliability of all factors. The highest Cronbach Alpha factor was 0.796 which indicates very high reliability. The Cronbach Alpha of each individual factor was: location mapping – 0.769, visual identification – 0.796, survivor surveillance – 0.621, system awareness – 0.621, secure connectivity – 0.607, search mobility – 0.578, and operator robot teaming – 0.643 (table 8). Based on further analysis of Cronbach Alpha (if item is deleted), visual identification, survivor surveillance, search mobility, and operator robot teaming all have a component factor with a lower loading that could be removed to produce higher factor loadings. As such, items (SC3 – self extraction and SC4 – probability of detection) were removed and PCA was run again. The results produced did not yield higher factor loadings and the component results were considerablly lower. At the completion of the phase II EFA, seven factor categories consisting of 28 items derived from PCA were retained for this study.

CSE Cronbach Alpha. The reliability statistics for the CSE construct can be found in Table 9. The reliability of CSE measures was 0.796 which suggest strong reliability. All

Table 8. CVFs of USAR resulting from PCA

Rotated Component Matrix[a]

Item	Factor Name	Proposed CVF	Component 1	2	3	4	5	6	7	If item is deleted
SC15	Location Mapping	Spatial Modeling	0.777	0.085	-0.061	-0.033	0.206	-0.083	0.097	0.698
SC16		Waypoint Annotation	0.748	0.143	0.002	-0.007	0.236	-0.102	0.078	0.703
SC21		Thermal Imaging	0.649	0.145	0.179	0.074	-0.115	0.075	0.033	0.746
SC20		Range Finder	0.641	0.102	0.049	0.370	-0.008	0.108	-0.038	0.737
SC10		Area Coverage	0.515	-0.063	0.259	0.349	0.239	-0.214	0.038	0.749
SC24	Visual Identification	Camera Tilt	0.046	0.833	-0.003	0.278	0.128	0.117	-0.016	0.664
SC23		Camera Pan	-0.050	0.778	-0.036	0.335	0.073	0.181	0.037	0.733
SC25		Camera Field of View	0.305	0.721	0.161	-0.012	-0.033	-0.089	0.169	0.748
SC26		Real Time Video	0.258	0.616	0.333	-0.092	0.006	-0.094	0.005	0.809
SC12	Survivor Surveillence	Tumble Recovery	0.066	0.003	0.778	0.228	0.174	-0.045	-0.002	0.511
SC13		Hazard Detection	0.045	-0.032	0.756	0.141	0.033	0.080	0.073	0.550
SC14		2-way audio	0.024	0.172	0.670	-0.190	-0.116	0.083	0.048	0.569
SC17		Victim Indicators	0.090	0.291	0.464	-0.263	-0.057	0.030	0.013	0.612
SC28		Structural Senors	0.349	0.095	0.362	0.118	-0.048	-0.239	0.047	0.674
SC22	System Awareness	Seismic Detection	0.157	0.263	-0.160	0.705	-0.067	0.058	0.111	0.522
SC11		Sustained Speed	-0.001	0.017	0.210	0.553	0.404	-0.045	0.052	0.579
SC19		Void Detection	0.393	0.067	0.141	0.552	0.071	0.277	-0.072	0.529
SC27		Climbing Ability	0.017	0.108	0.074	0.480	0.064	-0.136	0.168	0.598
SC18		System Health	0.089	0.030	-0.131	0.449	0.090	0.390	-0.025	0.593
SC8	Secure Connectivity	Security	-0.001	0.047	0.028	0.159	0.727	0.149	-0.084	0.464
SC9		Line of Sight Communications	0.186	-0.023	-0.097	0.208	0.718	-0.056	0.085	0.458
SC7		Beyond Line of Sight Communications	0.133	0.093	0.048	-0.175	0.601	0.206	0.134	0.590
SC5	Search Mobility	Lighting Conditions	-0.192	0.065	-0.030	0.035	0.178	0.724	0.084	0.228
SC4		Probability of Detection	0.272	-0.031	0.319	-0.120	-0.082	0.592	0.191	0.711
SC6		Mobility	-0.386	0.134	-0.022	0.131	0.306	0.589	0.081	0.396
SC2	Operator Robot Teaming	Operator Disengagement	0.036	0.073	0.020	0.156	0.011	0.043	0.864	0.311
SC1		Remote Information Sharing	0.000	0.088	0.038	0.066	0.177	0.044	0.768	0.461
SC3		Self Extraction	0.209	-0.065	0.139	-0.017	-0.147	0.372	0.524	0.707
		Cronbach's Alpha -->	0.769	0.796	0.637	0.621	0.607	0.578	0.643	

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.
a Rotation converged in 8 iterations.

cases were included in the analysis and the mean of all ten results was 62.42. Additionally, shown in Table 8, are the Cronbach Alpha (if deleted) numbers. It should be noted that none of those number are higher than the initial reliability number. Thus, the reliability of the CSE construct is valid.

Table 9. Cronbach Alpha for CSE Construct

Case Processing Summary

		N	%
Cases	Valid	265	100.0
	Excluded[a]	0	0.0
	Total	265	100.0

a. Listwise deletion based on all variables in the procedure.

Scale Statistics

Mean	Variance	Std. Deviation	N of Items
62.42	15.093	3.885	10

Reliability Statistics

Cronbach's Alpha	N of Items
0.796	10

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted
CSE1	55.98	11.954	0.486	0.776
CSE2	56.63	11.400	0.432	0.792
CSE3	55.99	12.185	0.518	0.772
CSE4	56.28	12.598	0.460	0.779
CSE5	56.36	12.398	0.502	0.774
CSE6	55.78	13.548	0.321	0.793
CSE7	56.29	13.071	0.438	0.782
CSE8	56.21	12.521	0.522	0.772
CSE9	56.08	12.611	0.577	0.768
CSE10	56.19	12.747	0.542	0.772

The reliability statistics for the RES construct can be found in Table 10. The reliability of RES measures was 0.578 which suggest marginal reliability. All cases were included in the analysis and the mean of all ten results was 26.09. Additionally, shown in Table 10, are the Cronbach Alpha (if deleted) numbers. It should be noted that RES3 was above the overall alpha and was removed from further analysis. It was surmised that there may have been wording problems with the question or some other abnormality.

Table 10. Cronbach Alpha for RES Construct

Case Processing Summary

		N	%
Cases	Valid	265	100.0
	Excluded[a]	0	0.0
	Total	265	100.0

a. Listwise deletion based on all variables in the procedure.

Scale Statistics

Mean	Variance	Std. Deviation	N of Items
26.09	24.299	4.929	7

Reliability Statistics

Cronbach's Alpha	N of Items
0.578	7

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted
RES1	22.76	16.614	0.417	0.488
RES2	23.05	19.444	0.282	0.545
RES3	23.56	21.800	0.111	0.597
RES4	21.67	17.941	0.366	0.512
RES5	21.10	18.687	0.329	0.528
RES6	22.71	19.993	0.250	0.556
RES7	21.66	19.286	0.313	0.534

Multiple Linear Regression (MLR) was used to develop the predictive model to determine if there were any significant contribution of CVFs and CSE on USAR team members RES in addition to the contribution of the interaction of CVFs and CSE on USAR team members' RES. Using MLR within SPSS, the data showed that only one of the seven CVF categories was significant. That category was CVF1 or location mapping. The statistical significance of CVF1 was 0.013* which falls within (*) $p < 0.05$. Table 11 shows the statistical significance of CVF1.

Table 11. MLR of CVFs on interaction of CSE for RES

Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation	Skewness		Kurtosis	
	Statistic	Statistic	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic	Std. Error
CSE	265	5.10	**7.00**	**6.2423**	0.38850	-0.090	0.150	-0.391	0.298
Valid N (listwise)	265								

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	t	Sig.
1	(Constant)	4.063	0.990		4.106	0.000
	CVF1	0.174	0.070	0.183	2.494	**0.013***
	CVF2	-0.149	0.088	-0.114	-1.688	0.093
	CVF3	0.147	0.116	0.085	1.270	0.205
	CVF4	0.033	0.071	0.033	0.468	**0.640**
	CVF5	-0.023	0.057	-0.027	-0.407	**0.684**
	CVF6	-0.074	0.063	-0.080	-1.175	0.241
	CVF7	-0.024	0.048	-0.033	-0.508	**0.612**
	CSE	-0.120	0.131	-0.060	-0.916	0.361

p<.05 *

However, CVF4, CVF5, and CVF6 are on the opposite end of the spectrum of statistical significance. Further analysis revealed that CVFs four, five, and six were at the top end of the CSE scale. Given the 7-point Likert scale, the statistical mean of the CVF construct was 6.24. This suggests that the USAR team members have a high degree of computer self-efficacy. Given the descriptive statistics of the respondent population, these results appear to be accurate. The bulk of the population were males, ages 18 to 45 and Busch (1995) noted that males had significantly higher self-efficacy expectations requiring complex tasks in computer-based scenarios.

Findings

The results of the tests of the hypotheses are summarized in table 12. Additional data points used to derived the results can be found in Appendix D.

Table 12. Summary of Hypotheses Results

Hypotheses	Results
H_o1: There will be no significant contribution of USAR team members' Critical Value Factors by their Resistance to use USAR Robots	(Partially rejected) CVF1 is the only significant contribution to RES
H_o2: There is no significant contribution by USAR team members' Computer Self-Efficacy to their Resistance to use USAR Robots	Supported
Ho3: There is no significant contribution by the interaction effect between USAR team members' Critical Value Factors and Computer Self-Efficacy to their Resistance to use USAR Robots	(Partially rejected) only interaction between CSE and CVF1 has significant contribution to RES
H_o4-1: USAR team members' Resistance to use USAR Robots is not significantly differ among their Critical Value Factors and Computer Self-Efficacy, when controlled for age	Supported
H_o4-2: USAR team members' Resistance to use USAR Robots is no significant difference among Critical Value Factors and Computer Self-Efficacy, when controlled for gender.	(Partially rejected) only CVF3 has significant contribution to RES
H_o4-3: USAR team members' Resistance to use USAR Robots is not significantly different among Critical Value Factors and Computer Self-Efficacy, when controlled for prior participation in live USAR event.	(Partially rejected) interaction between CVF1 and CVF4 has significant contribution to RES
H_o4-4: USAR team members' Resistance to use USAR Robots is not significantly different among Critical Value Factors and Computer Self-Efficacy, when controlled for their years of USAR work experience.	(Partially rejected) interaction between CVF1 and CVF4 has significant contribution to RES
H_o4-5: USAR team members' Resistance to use USAR Robots is not significantly among between Critical Value Factors and Computer Self-Efficacy, when controlled for their organizational role	(Partially Rejected) only interaction between CSE and CVF1 has signification contribution to RES

Summary

This chapter outlined the approach and research methodology used to achieve the research goals of the study. The research method process (Figure 6) identified the three phases of research used to achieve reliable and generalizable results. Phase I of the research methods process consisted of the identification of system characteristics from literature as well as Keeney's (1999) approach to solicit CVFs important to USAR team members during search and rescue events. Phase II of the research consisted of the derivation of a 7-point Likert scale survey instrument to collect data for each of the propsed CVFs for USAR team members. This study also performed a Mahalanobis distance analysis to identify multivariate outliers. The results were inspected to ensure that any offending items did not detract from the reliability of each factor. Cronbach's Alpha was used to determine and validate reliability. EFA techniques were used to uncover the CVFs of USAR that influenced USAR team members resistance to use USAR robots. Phase III of the reseach method process performed confirmatory analysis of the conceptual model with MLR to confirm or reject each hypothsis.

In summary, it appears that USAR team members resist CVFs associated with location mapping of structures that they have to enter. Based on the results of the study, it appears that USAR team members do not resist CVFs associated with visual identification, survivor survellience, system awareness, secure connectivity, search mobility, or operator robot teaming. This study contributed to the IS body of knowledge by demonstrating what CVFs for USAR team members influence resistance to use USAR robots.

Chapter 5

Conclusions, Implications, Recommendations, and Summary

Conclusions

This chapter provides the conclusions, implications, recommendations for future research, and a summary of the study. Dicsussions regarding the studies main goal, research questions, and hypotheses are followed by a description of the contributions of the study to the body of knowledge, and finally, limitations of the study. The chapter ends with reccomendations for future research.

The main goal of this study was to empirically examine system characteristics and critical value factors (CVFs) that create resistance to the use of robots by USAR team members during disaster operations. The main goal was achieved by answering two research questions and addressing eight hypotheses. The two research questions were: What are the USAR robot system characteristics that are important for USAR team members when using specialized robots? What are the CVFs of the USAR system characteristics? An exhaustive literature review combined with the responses of an expert panel yielded 28 system characteristics that were considered important for USAR team members. The items were used to develop the survery instrument that was administered in the quantitative phase of this study. 26 system characteristics were indentifed in the literature, while two additional items were added as a result of the expert panel responses.

The study addressed recommendations for further research in assessing system characteristics for USAR team members which are important during a disaster event to assit in saving victims' lives without sacrificing their own lives. Moreover, the study addressed the need to identify the characteristics of the USAR robot systems that are important to USAR team members in order to mitigate their resistance to such robotic systems. The CVFs that were deemed important were impirically evaluated through EFA and PCA. The study found that USAR team members resist factors associated location mapping such as spatial modeling, waypoint analysis, thermal imaging, range finding, and area coverage. These items specifically deal with a USAR team members ability to enter, traverse, and exit a disaster location without harm. The results of this study also confirm the importance of noting that in the male dominated industry of first response, computer self-efficacy is very high and is not considered a factor of resistance. Of particular interest was the fact that none of the other CVFs created resistance for USAR team members. On the surface, it appears that the first responder population is technology savvy and are not overly concerned with the acceptance of robots in their workspace with the exception of using that technology to provide entry and exit strategies into dangerous locations.

Implications

This study has several implications in the field of IS. First, the study contributes to the body of knowledge by empirically identifying the CVFs of USAR that team members find important in disaster scenarios. Secondly, this study addressed the relationship between CVFs and CSE on the contribution to USAR team members as well as the interaction effect between USAR team members' CVFs and CSE to their RES to use USAR robots. The study determined that there was a significant positive impact from location mapping on RES of USAR team members to use USAR robots while the other six factors had almost no impact on team members resistance to use USAR robots. Lastly, this study identified characteristics of CVFs that are valued by USAR team memers, thereby assisting researchers and first responders in determining the best areas of focus for USAR endeavors.

Study Limitations

This study had three main limitiations. The first limitation was that the study measured data from a small population of first responders in one state, in one city, in a specifc geographic area. Further studies may be required using additional populations to better validate and enchance the generalizability of the results. The second limitation of this study is the under representation of women in the first responder community. While women represent a small subset of the first responder workforce, their voice needs to be heard in order to produce more robust solutions to accommodate all first reponders. The final limitation relates to the high self efficacy of the respondent population. Given the specifc geographic population of this study, further research in other areas may find the opportunity for different levels of CSE which would yield different results for this study.

Recommendations for Future Research

This research study empirically identified seven CVFs in USAR with 28 reliable characteristics that contribute to USAR team members RES. The study provided a solid theoretical foundation from which future studies can originate. First, this study was designed to empirically validate the construct of user resistance within IS as it relates to CVFs and CSE to derive characteristics that are important to USAR team members during disaster events. While the results of the study yielded some significant factors for RES, future studies may be warranted to examine and assess other constructs and items that are important to USAR team members which will ultimately lead to saving victims lives without sacrificing USAR team members' lives. Furthermore, future research could assess the needs of drone pilots flying missions in remote locations for observation, survellience, or search and rescue. With additional attempts to ascertain CVFs that lead to resistance of team members, greater understaning of the process workflow required to eliminate resistance in the operations loop between human and machine should be identified. As systems improve and resistance lowers, there is the opportunity for a symboitc relationship between man and machine that creates a world of opportunities. This thought process may lead to the need to establish new development methodologies and process workflows with focus on verification and validation of high functioning human robot teams in the future.

Summary

This study addressed the cruicial need of first responders to save victims lives without risking their own lives during disaster operations. The purpose of this research was to validate empirically a model in the context of USAR by discovering the CVFs of USAR for assessing user resisitance in the context of USAR robot use. Moreover, this research addressed the need to identify the characteristics of the USAR robot systems that are important to USAR team members in order to mitigate their resistance to such robotic systems. While there have been numerous attempts to improve the hardware used in search and rescue, very little research has sought to assess which CVFs are important to USAR team mebers in a disaster situation. Most of the research in the USAR space is limitied to producing better hardware, better communications, and better user interfaces for communication with the robot. In this study, after a review of literature of CVFs, a list of characteristics was derived with the help of an expert panel that would assess the CVFs that contribute to RES. The main research questions addressed in this study were:

RQ1: What are the USAR robot system characteristics that are important for USAR team members when using specialized robots?

RQ2: What are the CVFs of the USAR system characteristics?

RQ3: What is the contribution of CVFs and CSE on USAR team members' RES?

RQ4: What is the contribution of the interaction between CVFs and CSE on USAR team members' RES?

RQ5: Are there any significant differences on CVFs, CSE, and RES based on age, gender, prior experience with USAR events, years of USAR experience, and organizational role?

The specific hypotheses that this study addressed were:

H_o1: There are no statistically significant contribution of USAR team members' Critical Value Factors (CVFs) to their Resistance to use USAR Robots (RES).

H_o2: There are no statistically significant contribution of USAR team members' Computer Self-Efficacy (CSE) to their Resistance to use USAR Robots (RES).

H_o3: There are no statistically significant contribution of the interaction effect between USAR team members' Critical Value Factors (CVFs) and Computer Self-Efficacy (CSE) to their Resistance to use USAR Robots (RES).

H_o4a: USAR team members' Resistance to use USAR Robots (RES) are not statistically significant differ among their Critical Value Factors (CVFs) and Computer Self-Efficacy (CSE), when controlled for age.

H_o4b: USAR team members' Resistance to use USAR Robots (RES) are not statistically significant differ among their Critical Value Factors (CVFs) and Computer Self-Efficacy (CSE), when controlled for gender.

H_o4c: USAR team members' Resistance to use USAR Robots (RES) are not statistically significant differ among their Critical Value Factors (CVFs) and Computer Self-Efficacy (CSE), when controlled for prior participation in live USAR event (PLE).

H_o4d: USAR team members' Resistance to use USAR Robots (RES) are not statistically significant differ among their Critical Value Factors (CVFs) and Computer Self-Efficacy (CSE), when controlled for their years of USAR work experience (EXP).

H_o4e: USAR team members' Resistance to use USAR Robots (RES) are not statistically significant differ among their Critical Value Factors (CVFs) and Computer Self-Efficacy (CSE), when controlled for their organizational role (ORG).

To address these research questions and hypotheses, a three phase qualitiative and quantitative methology was employed. Phase I included an explatory analysis with an open-ended questionnaire that was completed by an expert panel of USAR researchers. The list of items gathered was combined with the list developed from the exhaustive literative review. An analysis, based on Keeney's (1999) approach procduced a list of characteristics which were used to develop the survey instrument for phase II of the study.

Phase II of the study focused on the creation, validation, and administration of a 7-point Likert scale survey instrument to the responded population. Results were collected and analyzed with pre-analysis data cleansing and reviews of the data for errrors such as response set or skewedness. Once validated, the data was empirically evaluated in phase III.

In Phase III, the model was validated using EFA-PCA and MLR to assess the influence of the CVFs on CSE as they related to RES. The results of the analysis and validation indicated that the CVFs of RES had a positive impact as it related to the location mapping factor. This study provided compelling evidence that the antecedents of location mapping are important to the success of USAR operations. This study also revealed that due to the high CSE of the population of first responders, CSE did not have a significant impact on the CVFs as they related to RES. The results were evaluated across factors of age, gender, years of experience, organizational role, and number of USAR events. At the end of CFA and MLR, the results and conclusions were discussed, interpreted, and compared with prior research. Implications of this study were then addressed, followed by the limitations of the research. Finally, recommendations for further research were presented. These results contributed to the body of knowledge for USAR team members success.

Appendix A

Open-Ended Qualitative Questionnaire

Dear Participants:

I am asking for your time and cooperation in gathering system characteristics and critical value factors that you feel are important in urban search and rescue (USAR) operations where robots are involved. A USAR robot is defined as a device which automatically or via remote control has the ability to search, extract, examine, or inspect the surroundings of a disaster site for the purpose of collection, processing, storing, displaying, as well as dissemination of information to USAR team members. System Characteristics are defined as features of the USAR robots' system that provide necessary function to the USAR team member. Critical Value Factors (CVFs) are defined as specific characteristics which make USAR robots valuable to USAR team members during disaster events. The system characteristics that are listed in this survey instrument were found after a review of resistance, value, and self-efficacy literation. The purpose of this study is to gather information to understand the critical value factors that will benefit USAR team members during disaster events.

The survey will take about 15 minutes to complete. Information that you have submitted will not be used against you in any way. Your participation is completely voluntary and you are free to exit at any time.

Regards,

Marion Brown
Graduate Student\Nova Southeastern University
Email: browmari@nova.edu

Participant Survey

Participant Letter for Anonymous Surveys NSU Consent to be in a Research Study Entitled

Assessing the Role of Critical Value Factors (CVFs) on Users' Resistance of Urban Search and Rescue Robotics

Who is doing this research study?

This person doing this study is Marion Brown with The College of Engineering and Computing. They will be helped by Dr. Yair Levy, Dr. James Parrish, and Dr. Marlon Clarke.

Why are you asking me to be in this research study?

You are being asked to take part in this research study because you are a first responder with a job description centered around saving lives in hazardous settings.

Why is this research being done?

The purpose of this study is to empirically uncover the important system characteristics and critical value factors that contribute to urban search and rescue team members' resistance to use urban search and rescue robots. The study is relevant, as it seeks to facilitate a better understanding of the role of critical value factors on users' resistance of urban search and rescue robotics.

What will I be doing if I agree to be in this research study?

You will be taking a one-time, anonymous survey. The survey will take approximately 25 minutes to complete.

Are there possible risks and discomforts to me?

This research study involves minimal risk to you. To the best of our knowledge, the things you will be doing have no more risk of harm than you would have in everyday life.

What happens if I do not want to be in this research study?

You can decide not to participate in this research and it will not be held against you. You can exit the survey at any time.

Will it cost me anything? Will I get paid for being in the study?

There is no cost for participation in this study. Participation is voluntary and no payment will be provided.

How will you keep my information private?

Your responses are anonymous. Information we learn about you in this research study will be handled in a confidential manner, within the limits of the law. To protect your anonymity, no personally identifiable information will be collected that would tie you to your responses. This data will be available to the researcher, the Institutional Review Board and other representatives of this institution, and any granting agencies (if applicable). All confidential data will be kept securely in a database until the completion of the study. All data will be kept for 36 months and destroyed after that time by electronic deletion of the records and shredding or any paper documents at a secure facility.

Who can I talk to about the study?

If you have questions, you can contact Marion Brown at (713) 614-8140 or Dr. Yair Levy at (954) 262-2006.

If you have questions about the study but want to talk to someone else who is not a part of the study, you can call the Nova Southeastern University Institutional Review Board (IRB) at (954) 262-5369 or toll free at 1-866-499-0790 or email at IRB@nova.edu.

Do you understand and do you want to be in the study?

If you have read the above information and voluntarily wish to participate in this research study, please click Next to begin the survey.

Open-Ended Qualitative Questionnaire

1. Human System Interaction

Human systems interaction is aligned with the human interaction and operator control of a USAR robot system. Please list five (or at least three) human systems interaction characteristics that are important to you in urban search and rescue. Examples include dashboard, lighting, operator ratio, and proficiency education.

1. ____

2. ____

3. ____

4. ____

5. ____

2. System Communications

System communications is aligned with the support for transmission of information to and from the robot to the operator. Please list five (or at least three) system communications characteristics that are important to you in urban search and rescue. Example include range - line of sight, security, expandable bandwidth, and range - beyond line of sight.

1. ____

2. ____

3. ____

4. ____

5. ____

Open-Ended Qualitive Questionnaire

3. System Mobility

System Mobility is aligned with the ability of the vehicle to move over various terrains while conducting operations. Please list five (or at least three) system mobility characteristics that are important to you in urban search and rescue scenarios. Examples include area of coverage, tumble recovery, sustained speed, and swimmer.

1. ____

2. ____

3. ____

4. ____

5. ____

2. System Sensing

System Sensing is aligned with the hardware and supporting software that allows the operator to receive input from the robot while searching for victims. Please list five (or at least three) system sensing characteristics that are important to you in urban search and rescue. Example include 2-way audio, hazard detection, spatial modeling, and thermal imaging

1. ____

2. ____

3. ____

4. ____

5. ____

Appendix B

Recruitment Letter and Survey

Participant Survey

Participants:

Thank you for your participation in this survey. My goal is to make the valuable work that you do safer for you and the victims that you rescue.

I am a Ph.D. candidate in information systems under the supervision of Dr. Yair Levy (http://cec.nova.edu/~levyy/), and asking for your time/cooperation in gathering system characteristics and critical value factors that you feel are important in urban search and rescue (USAR) operations where robots are involved. A USAR robot is defined as a device which automatically or via remote control has the ability to search, extract, examine, or inspect the surroundings of a disaster site for the purpose of collection, processing, storing, displaying, as well as dissemination of information to USAR team members. System Characteristics are defined as features of the USAR robot system that provide necessary function to the USAR team member. Critical Value Factors (CVFs) are defined as specific characteristics which make USAR robots valuable to USAR team members during disaster events. The system characteristics that are listed in this survey instrument were found by delivering a previous questionnaire to another group of USAR team members. The purpose of this study is to gather information to understand the critical value factors that will benefit USAR team members during disaster events.

The survey will take about 20 to 25 minutes to complete. Your participation is completely voluntary and you are free to exit at any time.

Regards,

Marion Brown (Ph.D. Candidate)
Nova Southeastern University
Email: browmari@nova.edu

Participant Survey

Participant Letter for Anonymous Surveys NSU Consent to be in a Research Study Entitled

Assessing the Role of Critical Value Factors (CVFs) on Users' Resistance of Urban Search and Rescue Robotics

Who is doing this research study?

This person doing this study is Marion Brown with The College of Engineering and Computing. They will be helped by Dr. Yair Levy, Dr. James Parrish, and Dr. Marlon Clarke.

Why are you asking me to be in this research study?

You are being asked to take part in this research study because you are a first responder with a job description centered around saving lives in hazardous settings.

Why is this research being done?

The purpose of this study is to empirically uncover the important system characteristics and critical value factors that contribute to urban search and rescue team members' resistance to use urban search and rescue robots. The study is relevant, as it seeks to facilitate a better understanding of the role of critical value factors on users' resistance of urban search and rescue robotics.

What will I be doing if I agree to be in this research study?

You will be taking a one-time, anonymous survey. The survey will take approximately 25 minutes to complete.

Are there possible risks and discomforts to me?

This research study involves minimal risk to you. To the best of our knowledge, the things you will be doing have no more risk of harm than you would have in everyday life.

What happens if I do not want to be in this research study?

You can decide not to participate in this research and it will not be held against you. You can exit the survey at any time.

Will it cost me anything? Will I get paid for being in the study?

There is no cost for participation in this study. Participation is voluntary and no payment will be provided.

How will you keep my information private?

Your responses are anonymous. Information we learn about you in this research study will be handled in a confidential manner, within the limits of the law. To protect your anonymity, no personally identifiable information will be collected that would tie you to your responses. This data will be available to the researcher, the Institutional Review Board and other representatives of this institution, and any granting agencies (if applicable). All confidential data will be kept securely in a database until the completion of the study. All data will be kept for 36 months and destroyed after that time by electronic deletion of the records and shredding or any paper documents at a secure facility.

Who can I talk to about the study?

If you have questions, you can contact Marion Brown at (713) 614-8140 or Dr. Yair Levy at (954) 262-2006.

If you have questions about the study but want to talk to someone else who is not a part of the study, you can call the Nova Southeastern University Institutional Review Board (IRB) at (954) 262-5369 or toll free at 1-866-499-0790 or email at IRB@nova.edu.

Do you understand and do you want to be in the study?

If you have read the above information and voluntarily wish to participate in this research study, please click Next to begin the survey.

Please tell us how many live Urban Search and Rescue events you have participated in.

- none
- 1 - 6
- 7 - 11
- 12 - 16
- 17 - 25
- greater than 25

How many years have you been a first responder?

- 0 - 5 years
- 6 - 10 years
- 11 - 16 years
- 17 - 25 years
- 26 - 30 years
- 31 - 35 years
- 36 or more years

Computer Self Efficacy

Please rate the following 10 questions on the 7-point scale from:
1 = Entirely Disagree to 7 = Entirely Agree
to indicate how important each of these system characteristics is when using an Urban Search and Rescue (USAR)
operations system.

CSE1. I can always manage to solve difficult problems if I try hard enough.

1 Entirely Disagree	2 Mostly Disagree	3 Somewhat Disagree	4 Neither Agree Nor Disagree	5 Somewhat Agree	6 Mostly Agree	7 Entirely Agree
○	○	○	○	○	○	○

CSE2. If someone opposes me, I can find the means and ways to get what I want.

1 Entirely Disagree	2 Mostly Disagree	3 Somewhat Disagree	4 Neither Agree Nor Disagree	5 Somewhat Agree	6 Mostly Agree	7 Entirely Agree
○	○	○	○	○	○	○

CSE3. It is easy for me to stick to my aims and accomplish my goals.

1 Entirely Disagree	2 Mostly Disagree	3 Somewhat Disagree	4 Neither Agree Nor Disagree	5 Somewhat Agree	6 Mostly Agree	7 Entirely Agree
○	○	○	○	○	○	○

CSE4. I am confident that I could deal efficiently with unexpected events.

1 Entirely Disagree	2 Mostly Disagree	3 Somewhat Disagree	4 Neither Agree Nor Disagree	5 Somewhat Agree	6 Mostly Agree	7 Entirely Agree
○	○	○	○	○	○	○

CSE5. Thanks to my resourcefulness, I know how to handle unforeseen situations.

1 Entirely Disagree	2 Mostly Disagree	3 Somewhat Disagree	4 Neither Agree Nor Disagree	5 Somewhat Agree	6 Mostly Agree	7 Entirely Agree
○	○	○	○	○	○	○

CSE6. I can solve most problems if I invest the necessary effort.

1 Entirely Disagree	2 Mostly Disagree	3 Somewhat Disagree	4 Neither Agree Nor Disagree	5 Somewhat Agree	6 Mostly Agree	7 Entirely Agree
○	○	○	○	○	○	○

CSE7. I can remain calm when facing difficulties because I can rely on my coping abilities.

1 Entirely Disagree	2 Mostly Disagree	3 Somewhat Disagree	4 Neither Agree Nor Disagree	5 Somewhat Agree	6 Mostly Agree	7 Entirely Agree
○	○	○	○	○	○	○

CSE8. When I am confronted with a problem, I can usually find several solutions.

1 Entirely Disagree	2 Mostly Disagree	3 Somewhat Disagree	4 Neither Agree Nor Disagree	5 Somewhat Agree	6 Mostly Agree	7 Entirely Agree
○	○	○	○	○	○	○

CSE9. If I am in trouble, I can usually think of a solution.

Entirely Disagree	Mostly Disagree	Somewhat Disagree	Neither Agree Nor Disagree	Somewhat Agree	Mostly Agree	Entirely Agree
○	○	○	○	○	○	○

CSE10. I can usually handle whatever comes my way.

Entirely Disagree	Mostly Disagree	Somewhat Disagree	Neither Agree Nor Disagree	Somewhat Agree	Mostly Agree	Entirely Agree
○	○	○	○	○	○	○

System Characteristics

Please rate the following 26 questions on the 7-point scale from:
1 = Not Important to 7 = Extremely Important

	1 Not Important	2 Not Very Important	3 Slightly Important	4 Neutral	5 Important	6 Very Important	7 Extremely Important
SC1. Remote Information Sharing							
SC2. Operator Disengagement							
SC3. Self-Extraction							
SC4. Probability of Detection							
SC5. Lighting Conditions							
SC6. Mobility							
SC7. Beyond Line of Sight Communications							
SC8. Security						●	
SC9. Line of Sight Communications							
SC10. Area Coverage							

	1 Not Important	2 Not Very Important	3 Slightly Important	4 Neutral	5 Important	6 Very Important	7 Extremely Important
SC11. Sustained Speed	○	○	○	○	○	○	○
SC12. Tumble Recovery	○	○	○	○	○	○	○
SC13. Hazard Detection	○	○	○	○	○	○	○
SC14. 2 - way audio	○	○	○	○	○	○	○
SC15. Spatial Modeling	○	○	○	○	○	○	○
SC16. Waypoint Annotation	○	○	○	○	○	○	○
SC17. Victim Indicators	○	○	○	●	○	○	○
SC18. System Health	○	○	○	○	○	○	○
SC19. Void Detection	○	○	○	○	○	○	○
SC20. Range Finder	○	○	○	○	○	○	○
SC21. Thermal Imaging	○	○	○	○	○	○	○
SC22. Seismic Detection	●	○	○	○	○	○	○
SC23. Camera Pan	○	○	○	○	○	○	○
SC24. Camera Tilt	○	○	○	○	○	○	○

	1 Not Important	2 Not Very Important	3 Slightly Important	4 Neutral	5 Important	6 Very Important	7 Extremely Important
SC25. Camera Field of View							
SC26. Real Time Video							

User Perceptions

Please rate the following 7 questions on the 7-point scale from:
1 = Entirely Disagree to 7 = Entirely Agree

RES1. I feel that urban search and rescue robotics will create a loss of status in my current job.

1 Entirely Disagree	2 Mostly Disagree	3 Somewhat Disagree	4 Neither Agree Nor Disagree	5 Somewhat Agree	6 Mostly Agree	7 Entirely Agree

RES2. I feel that urban search and rescue robotics will affect my salary or potential increase in salary.

1 Entirely Disagree	2 Mostly Disagree	3 Somewhat Disagree	4 Neither Agree Nor Disagree	5 Somewhat Agree	6 Mostly Agree	7 Entirely Agree

RES3. I feel that urban search and rescue robotics will alter interpersonal relationships.

1 Entirely Disagree	2 Mostly Disagree	3 Somewhat Disagree	4 Neither Agree Nor Disagree	5 Somewhat Agree	6 Mostly Agree	7 Entirely Agree

RES4. I feel that urban search and rescue robotics will change my job duties.

1 Entirely Disagree	2 Mostly Disagree	3 Somewhat Disagree	4 Neither Agree Nor Disagree	5 Somewhat Agree	6 Mostly Agree	7 Entirely Agree

RES5. I feel that urban search and rescue robotics will change my decision making approach.

1 Entirely Disagree	2 Mostly Disagree	3 Somewhat Disagree	4 Neither Agree Nor Disagree	5 Somewhat Agree	6 Mostly Agree	7 Entirely Agree
○	○	○	○	○	○	○

RES6. I feel that urban search and rescue robotics will create a loss of power for me in my current position.

1 Entirely Disagree	2 Mostly Disagree	3 Somewhat Disagree	4 Neither Agree Nor Disagree	5 Somewhat Agree	6 Mostly Agree	7 Entirely Agree
○	○	○	○	○	○	○

RES7. I feel that urban search and rescue robotics will create a personal level of uncertainty on the purpose of the implementation.

1 Entirely Disagree	2 Mostly Disagree	3 Somewhat Disagree	4 Neither Agree Nor Disagree	5 Somewhat Agree	6 Mostly Agree	7 Entirely Agree
○	○	○	○	○	○	○

What is your gender?

○ Female

○ Male

Please select the range that best represents your age.

○ 18 - 24

○ 25 - 31

○ 32 - 45

○ 45 - 54

○ 55 - 64

○ 65 and over

What is your organizational role (your job title)?

[ ]

Appendix C

Table 6. System Characteristics of USAR from Phase I: Qualitative Method

No.	Proposed Factors	System Characteristics
1	HSI	Remote Information Sharing
2		Operator Disengagement
3		Probability of Detection
4		Self Extraction
5		Lighting Conditions
6		Mobility
7	SYSCOMM	Beyond Line of Sight Communications
8		Security
9		Line of Sight Communications
10	SYSMOB	Area Coverage
11		Sustained Speed
12		Tumble Recovery
13		**Climbing Ability**
14	SYSSENS	Camera Pan
15		Camera Tilt
16		Camera Field of View
17		Real Time Video
18		Seismic Detection
19		Thermal Imaging
20		Hazard Detection
21		2-way audio
22		Spatial Modeling
23		Waypoint Annotation
24		Victim Indicators
25		System Health
26		Void Detection
27		Range Finder
28		**Structural Senors**

Appendix D

ANCOVA Tables

Interaction between CVFs and CSE. The following tables provide data points for the hypotheses found in table 12.

Table 13. Significant difference of CVFs and *CSE on RES by Gender*

N = 263			
Construct	df	F	sig
CSE	1	0.187	0.665
CVF1	1	0.217	0.642
CVF2	1	1.369	0.243
CVF3	1	5.286	0.023*
CVF4	1	2.072	0.151
CVF5	1	0.637	0.425
CVF6	1	0.164	0.686
CVF7	1	0.003	0.953
RES	1	2.896	0.090

p<.05 *
p<.01 **
p<.001 ***

Table 14. Significant difference of CVFs and *CSE on RES by Age*

N = 260			
Construct	df	F	Sig
CSE	4	2.075	0.084
CVF1	4	1.350	0.252
CVF2	4	0.453	0.770
CVF3	4	1.062	0.376
CVF4	4	0.585	0.673
CVF5	4	1.282	0.277
CVF6	4	1.555	0.187
CVF7	4	0.142	0.966
RES	4	2.205	0.069

p<.05 *
p<.01 **
p<.001 ***

Table 15. Significant difference of CVFs and *CSE on RES by Organization Role*

N = 259			
Construct	df	F	sig
CSE	5	0.150	0.980
CVF1	5	2.416	0.037*
CVF2	5	0.956	0.445
CVF3	5	0.835	0.526
CVF4	5	0.926	0.464
CVF5	5	1.017	0.408
CVF6	5	1.424	0.216
CVF7	5	0.815	0.540
RES	5	24.206	0.000

p<.05 *
p<.01 **
p<.001 ***

Table 16. Significant difference of CVFs and *CSE on RES by Number of USAR Events*

N = 259			
Construct	df	F	Sig
CSE	5	1.602	0.160
CVF1	5	9.987	0.000***
CVF2	5	0.954	0.446
CVF3	5	1.750	0.124
CVF4	5	3.955	0.002**
CVF5	5	1.037	0.396
CVF6	5	1.526	0.182
CVF7	5	0.238	0.945
RES	5	0.971	0.436

p<.05 *
p<.01 **
p<.001 ***

Table 17. Significant difference of CVFs and CSE on RES by Num. of Years as First Responder

N = 258			
Construct	df	F	Sig
CSE	6	0.891	0.502
CVF1	6	3.850	0.001***
CVF2	6	0.424	0.862
CVF3	6	2.106	0.053
CVF4	6	3.257	0.004**
CVF5	6	0.594	0.735
CVF6	6	1.032	0.405
CVF7	6	0.510	0.800
RES	6	2.659	0.016**

p<.05 *
p<.01 **
p<.001 ***

Appendix E

MEMORANDUM

To: **Marion Brown**

From: **Ling Wang, Ph.D.,**
Center Representative, Institutional Review Board

Date: **October 6, 2017**

Re: **IRB #: 2017-589; Title, "Assessing the Role of Critical Value Factors (CVFs) on Users' Resistance of Urban Search and Rescue Robotics"**

I have reviewed the above-referenced research protocol at the center level. Based on the information provided, I have determined that this study is exempt from further IRB review under **45 CFR 46.101(b) (Exempt Category 2)**. You may proceed with your study as described to the IRB. As principal investigator, you must adhere to the following requirements:

1) CONSENT: If recruitment procedures include consent forms, they must be obtained in such a manner that they are clearly understood by the subjects and the process affords subjects the opportunity to ask questions, obtain detailed answers from those directly involved in the research, and have sufficient time to consider their participation after they have been provided this information. The subjects must be given a copy of the signed consent document, and a copy must be placed in a secure file separate from de-identified participant information. Record of informed consent must be retained for a minimum of three years from the conclusion of the study.

2) ADVERSE EVENTS/UNANTICIPATED PROBLEMS: The principal investigator is required to notify the IRB chair and me (954-262-5369 and Ling Wang, Ph.D., respectively) of any adverse reactions or unanticipated events that may develop as a result of this study. Reactions or events may include, but are not limited to, injury, depression as a result of participation in the study, life-threatening situation, death, or loss of confidentiality/anonymity of subject. Approval may be withdrawn if the problem is serious.

3) AMENDMENTS: Any changes in the study (e.g., procedures, number or types of subjects, consent forms, investigators, etc.) must be approved by the IRB prior to implementation. Please be advised that changes in a study may require further review depending on the nature of the change. Please contact me with any questions regarding amendments or changes to your study.

The NSU IRB is in compliance with the requirements for the protection of human subjects prescribed in Part 46 of Title 45 of the Code of Federal Regulations (45 CFR 46) revised June 18, 1991.

Cc: Yair Levy, Ph.D.
Ling Wang, Ph.D.

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