

Information Technology to the Rescue? Explaining the Acceptance of Emergency Response Information Systems by Firefighters

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Abstract—**Improving the efficacy of emergency responses with digital means is receiving increasing attention. Currently, several innovative information technologies and systems are being developed to raise the situation awareness of first responders like firefighters. Among them, emergency response information systems (ERIS) appear to provide a particularly promising platform, which helps to gather, analyze, and share relevant information during emergencies. However, the conditions under which firefighters accept or reject such systems remain unclear. Existing theories explain the acceptance of information technologies only on a general level that does not consider the specific usage constraints existing in the firefighter domain. To fill this literature gap, we propose a detailed, domain-specific acceptance model with factors that explain the acceptance of ERIS by firefighters. It combines findings of the user satisfaction and the technology acceptance literature and was developed based on the input of 82 domain experts. An evaluation of the acceptance model in a survey with 212 firefighters from Germany indicates that it is effective in predicting a firefighter's intention to use an ERIS. The identified acceptance factors provide guidance for the design and evaluation of ERIS, enabling the so far mostly theoretical benefits of ERIS to be transferred into practical applications more effectively.**

Index Terms—**Acceptance Factors, Emergency Services, Firefighter Information Technologies, Model Development, Partial Least Squares, Quantitative Research**

Managerial Relevance Statement—**The presented acceptance model provides a unique overview of the factors determining the acceptance and usage of emergency response information systems (ERIS) by firefighters. Achieving an in-depth understanding of the practical requirements and constraints**

governing the usage of ERIS is important as they are meant to support the coordination of emergency operations with lives at stake. The presented acceptance model can thus provide benefits for several stakeholder groups: ERIS developers can build upon the identified acceptance factors and the feedback of 212 experienced firefighters to improve the design of their systems. ERIS procurers can use the acceptance factors as a benchmark to evaluate existing ERIS and identify the best suited candidate for their fire department. Eventually, the proposed acceptance model can also benefit firefighters as the actual system users. By considering the identified acceptance factors in their design, ERIS can better meet the practical needs and will thus likely be better able to support time-critical operations on site.

I. INTRODUCTION

With increasingly occurring human-made and natural disasters such as terrorist assaults, earthquakes, or wildfires, improving the efficacy of emergency first responders receives more attention around the globe. Over the last years, significant efforts have been made to improve emergency response processes and to provide a better infrastructure for first responders such as firefighters [1]. While these efforts have led to notable achievements, the efficacy of emergency responses remains considerably dependent on the ability of incident commanders to adapt to the encountered situation and make context-dependent decisions on how to proceed [2, 3]. As a critical determinant for the quality of such decisions, the situation awareness – that is, the perception of environmental elements, the comprehension of their meaning, and the projection of their future status – has been widely emphasized in the literature [4, 5]. Typically, however, firefighters still have limited access to real-time information about the emergency site such as the locations of responding units, the status of available resources, or environmental conditions at the incident area. Increasing the situation awareness hence continues to be an important goal to make emergency responses more effective.

To better achieve this goal, several approaches to utilize emergency response information systems (ERIS) and other novel firefighter information technologies (FITs) have recently been described in the literature [6].

Among them, ERIS appear to be particularly suited to improve the current state of the art, because such systems introduce a versatile, generic platform that facilitates the gathering, analysis, and communication of mission-critical information in order to support the dynamic management of the resources available on site. In general, ERIS can hence even establish the technological basis required to integrate the information delivered by other novel FITs such as digital plans, intelligent clothing, drones, or ground robots.

Despite their potential to improve the situation awareness, the acceptance of ERIS in practice has remained rather unexplored, however. So far, the use of ERIS is instead suggested mainly due to their innovative features and their assumed potential to expedite emergency responses. Such technology-driven approaches risk neglecting that information technologies are particularly delicate artifacts for emergency responders, because several tight usage constraints exist in practice [7]. Any gain in functionality hence needs to be weighed against the additional efforts or restrictions that arise for the users. Since the factors that positively or negatively impact the acceptance of ERIS hardly have been explored so far, it remains unclear, if and under which conditions such systems might indeed be viewed as beneficial and used by firefighters.

To provide insights into the usage conditions, we present the results of a study, in which we explored the factors that determine the acceptance or rejection of ERIS by firefighters. Using generic theories, which explain the acceptance of information technologies, as theoretical foundation and considering the specific usage constraints existing in the firefighter domain, we examine the following research questions: "*Which factors determine the acceptance of emergency response information systems by firefighters? How do the identified factors influence the design of emergency response information systems?*"

As a means to answer these questions, we introduce a new acceptance model that explains the acceptance of ERIS and propose a corresponding measurement instrument. Following methodological guidelines that we adopted from the literature [8, 9], the acceptance model and the measurement instrument were iteratively developed based on the feedback of 10 domain experts and 72 pilot testers. The final version was then used to examine the acceptance of ERIS in a survey of 212 German firefighters, which had practical experiences with these systems. The developed acceptance model introduces a new theoretical basis that considers several domain-specific factors to explain the acceptance of ERIS. By considering the specific usage constraints, which exist in the firefighter domain, we complement existing general-purpose acceptance theories with a tailor-made perspective that might also be able to better explain the acceptance of other innovative FITs. The survey results moreover provide a unique overview of the factors that determine the acceptance of ERIS. As these factors should be fulfilled to facilitate the acceptance, the survey results provide guidance for the design of new ERIS and can be used as a benchmark to evaluate existing systems.

We proceed as follows: in the next section, we describe the concept of ERIS and existing acceptance theories in detail. We also argue why these theories do not adequately describe the acceptance of FITs. Against this background, we introduce a new acceptance model to explain the usage of ERIS and describe its development in section 3. Section 4 contains the results of the survey that we conducted to evaluate the acceptance of ERIS based on the final version of our model. We discuss the results and elaborate on the implications for academia and practice in section 5. Section 6 concludes the paper and gives an outlook on future research.

II. Theoretical Background and Related Work

A. Emergency Response Information Systems for Firefighters

To increase the situation awareness on site, several novel FITs are being discussed in academia and practice. While many of them still rather exist on the drawing board, a recent survey found that especially ERIS have already gained a more widespread diffusion in practice [7]. Generally, an ERIS introduces a versatile platform to gather, analyze, and communicate mission-critical information to support the dynamic management and coordination of emergency operations [3, 10-13]. It is meant to support the incident commander as well as the responding units. As versatile systems, ERIS can basically support operations ranging from daily routine to large-scale disasters, in which multiple units from different agencies must be coordinated [10-13]. ERIS were hence found to be of particular interest to practitioners in a recent study [6].

Various approaches to realize ERIS have been presented in academia and practice. The approaches differ with respect to the platform design and the provided functionality, but also share several basic features. In the following, we illustrate some of these features using an exemplary approach from practice (see Fig. 1, [13]). Typically, ERIS maintain inventories with information about the units responding to the incident and additionally available resources. The information regarding the responding units consists of the call sign to initiate radio contact, the number and qualification of the unit members, and the type of apparatus the unit operates (see Fig. 1, top left). To better structure larger-scaled responses, the units can be assigned to different operation sections [14]. In the illustrated approach, these sections are depicted in hierarchical order according to the command structure (see Fig. 1, bottom left). A situation map moreover depicts spatial information about the incident area such as the positions of units, danger zones, or staging areas (see Fig. 1, right). It can be based on a geographical map, but also utilize building plans or aerial images delivered by a drone.

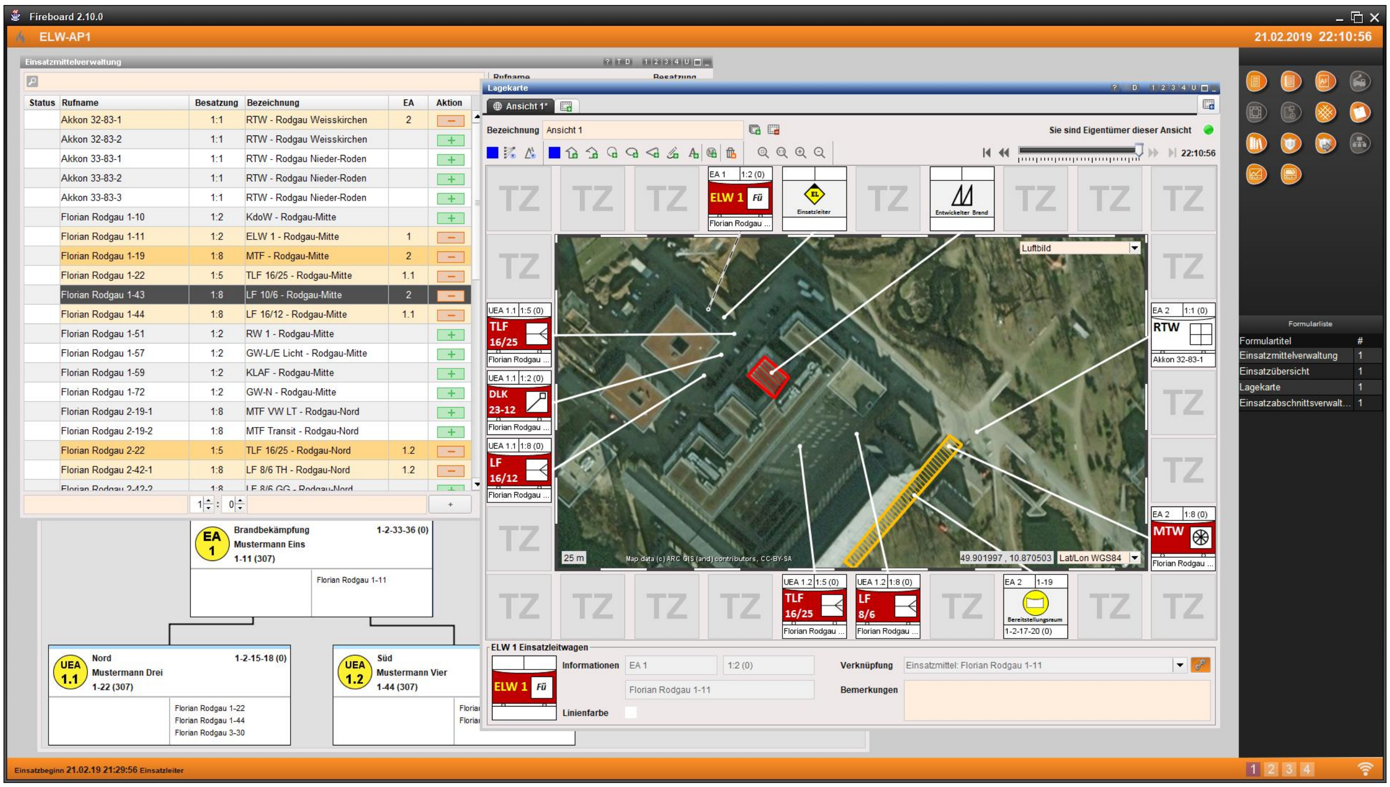

Fig. 1. Exemplary Implementation of an ERIS in the software “Fireboard”

Regarding the provided functionality, three basic categories or evolutionary stages of ERIS can be distinguished. They differ with respect to the way, in which real-time data from the incident site is obtained and utilized. Basic ERIS introduce a platform to present and communicate information, which has been manually entered by its users [10-13, 15]. During an emergency response, such a system must be constantly fed with updates by hand. Most currently available systems belong to this category [10-13]. In addition, literature also describes ERIS of a second category, which (partially) automate the data input. In particular, such ERIS are able to obtain real-time data from sensor networks, which have been developed to capture positions of responding units, levels of water tanks, weather conditions, etc. [3, 16-20]. In principle, an ERIS of this category could hence also be used to gather data that is generated by other emerging FITs such as drones, ground robots, or intelligent clothing [6]. While the data input is automated, however, the data must still be processed manually to derive appropriate reactions and commands. This step is partially automated by ERIS of the third category, which also provide decision-making support. ERIS belonging to this category calculate and actively suggest possible commands based on the received information [21-23].

B. Acceptance of Information Technologies

To explain the acceptance of information technologies and systems, several generic theories have been proposed in the literature. For example, Moore and Benbasat adapted the Diffusion of Innovations Theory to describe the *Relative Advantage*, *Compatibility*, and *Ease of Use* of information technologies as key factors governing their adoption by the user [24]. The Model of PC Utilization (MPCU) specifically explains the acceptance of personal computers and introduces additional factors like *Facilitating Conditions* or *Job-fit* [25]. One of the most widespread theories on the acceptance of information systems instead is based on the Theory of Reasoned Action. This theory states that, in general, an individual's *Attitude* and the *Subjective Norm* will influence the *Intention* toward a specific behavior and ultimately the *Behavior* itself [26]. It was later supplemented with *Perceived Behavioral Control* as an additional factor in the Theory of Planned Behavior [27]. As a technology-specific successor of these theories, the Technology Acceptance Model (TAM) evolved [28]. It introduced *Perceived Usefulness* and *Perceived Ease of Use* as the main factors affecting the *Attitude* towards the technology but left out *Subjective Norm* and *Perceived Behavioral Control*. Revised versions (TAM2 and TAM3) found the *Attitude* to be omittable and established a direct link from *Perceived Usefulness* and *Perceived Ease of Use* to the *Intention* to use a technology [29-31].

Despite their different roots, the before-mentioned theories have several acceptance factors in common. The Unified Theory of Acceptance and Use of Technology (UTAUT) is an attempt to integrate the acceptance factors of these theories into a unified approach [32]. The UTAUT summarizes the most important factors of existing theories in four combined constructs: *Performance Expectancy*, *Effort Expectancy*, *Social Influence*, and *Facilitating Conditions*. The first three constructs were found to influence the *Intention* to use a technology while *Facilitating Conditions* directly influences *Use Behavior*. The revised version (UTAUT2) also introduces a connection between *Facilitating Conditions* and *Intention* for certain domain contexts [33]. The introduced technology acceptance models concentrate on the user's perceptions about using a system to predict the system's acceptance. In contrast, the user satisfaction literature aims to explain a user's satisfaction with a system based on the actual characteristics of the system and the information it provides [34]. It proposes that *System Satisfaction* and *Information Satisfaction* are mainly determined by the *System Quality* and *Information Quality*. For these two quality measures, several factors have been identified as determinants [35]. In an effort to combine the findings of the user satisfaction literature and the technology acceptance literature, Wixom and Todd showed that *System Satisfaction* and *Information Satisfaction* are sufficient antecedences of the TAM's *Perceived Usefulness* and *Perceived Ease of Use* [36].

C. Acceptance of Emergency Response Information Systems

The acceptance of information technologies and IT-based systems already has been explored intensively during the last decade, especially in business [37, 38] and private usage contexts [39, 40]. However, literature emphasizes that the firefighter and the emergency domain are shaped by several specific characteristics that set it apart from business or private contexts [1, 3, 41]. It hence appears necessary to determine in how far the acceptance of information technologies and systems has already been examined in this specific domain. Therefore, we conducted a systematic literature review following the guidelines given by Webster and Watson [42]. To obtain a broad overview, we searched the databases of ScienceDirect, SpringerLink, and EBSCOhost as well as the digital libraries of ACM, AIS, IEEE, and the particularly relevant ISCRAM community. We combined search terms such as "firefighter" and "emergency" with "acceptance" and "adoption" to identify prior work related to our study. The titles and abstracts of the resulting articles were inspected for relevance and irrelevant articles were excluded. For the sake of clarity, we limited the analysis to information technologies used within emergency organizations and omitted alerting and social media systems involving civilians. Based on the references of the remaining articles, we conducted forward and backward searches to identify additional related work. In the following, we highlight the areas, in which the acceptance of information technologies and systems has been investigated in the emergency domain.

We found that the acceptance of information technologies has been addressed most intensively in the healthcare domain. However, most papers concentrate on clinical usage scenarios rather than emergency responses. For instance, Despont-Gros et al. studied the human-computer interaction with data acquisition devices in a hospital [43]. Moores and Handayani et al. developed TAM-based acceptance models for information technologies in clinics [44, 45]. Neill et al. combined existing acceptance models to study the adoption of wearable technologies in hospitals [46]. One of the few papers concentrating on emergency responses used the UTAUT to examine the acceptance of mobile devices in the emergency medical service [47]. Elmasllari and Reiners moreover identified acceptance factors for electronic triage systems [48].

In other emergency domains, technology acceptance has been studied only sporadically. A refined TAM was proposed to explain the acceptance of mobile data terminals in a UK police force [49, 50]. Kurkinen used the TAM to examine the effects of age on the acceptance of technologies by police officers [51]. Aedo et al. developed cooperation strategies for the multi-organizational adoption of emergency management information systems in large-scale disasters [52]. In a multiple case study, the Task-Technology-Fit (TTF) Model was used to examine the adoption of the RFID technology in emergency management [53]. Prasanna et al. developed an acceptance model for information systems in emergency operation centers [54].

Technology acceptance in the firefighter domain has been studied by only a few authors so far. Using fire departments as example, Santos et al. developed a theoretical model to assess an emergency response organization's maturity in adopting novel technologies [55]. A quantitative study moreover used the TTF Model to evaluate the practical potential of ERIS and other emerging FITs [7]. Based on interviews with domain experts, a subsequent qualitative study identified an initial set of factors that might foster or impede the use of ERIS and the other FITs [6]. However, the identified factors have not yet been evaluated.

Overall, we found that the body of literature treating technology acceptance in the emergency domain is still quite small. When limiting the scope to the on-site response to emergencies or to the firefighter domain, related work narrows to only a few studies. While especially ERIS are supposed to have a significant potential to increase the situation awareness of firefighters, prior research has mainly focused on determining general design principles and information demands of various stakeholders [1, 3, 20, 41]. It therefore remains difficult to assess under which circumstances ERIS might be accepted and used in practice.

III. Model and Instrument Development

To close this literature gap and identify the factors governing the practical adoption of ERIS, we propose a new, tailor-made acceptance model that explains the adoption and use of ERIS by firefighters. Building upon the German firefighter landscape as a specific yet typical field of study, the proposed model deliberately considers the usage constraints that exist in the firefighter domain. Therefore, we combined generic theories like the TAM or UTAUT with domain-specific acceptance factors that we derived from the firefighting literature. In addition, we developed a corresponding measurement instrument. To ensure a rigorous development of the acceptance model and the associated measurement instrument, we followed established guidelines for instrument development [8, 9]. In the following, we describe the development process. We begin by discussing the hypotheses that led to the initial acceptance model and instrument. We then explain the conducted revisions and present the final instrument that was used to examine the acceptance of ERIS.

A. Initial Acceptance Model

As a foundation for our acceptance model, we adopted the approach of Wixom and Todd [36] that integrates the findings of the technology acceptance and user satisfaction literature into a unified model (see section II.B). However, taking recent developments of the underlying theories and the specific conditions in the firefighter domain into account, we made several modifications to enhance the original model. The resulting model containing all presumed acceptance factors and their relationships is displayed in Fig. 2 later on.

Like the original model proposed by Wixom and Todd, the right-hand part of our model explains the acceptance of information technologies or systems. We extensively refined this part since the original model incorporated the initial and meanwhile outdated version of TAM with *Perceived Usefulness* and *Perceived Ease of Use* determining *Attitude*. As explained before, *Attitude* has been found to be omittable in more recent approaches like the refined TAM versions or the UTAUT [29-32]. Consequently, we also omitted *Attitude* and instead assumed a direct path toward *Intention*. Furthermore, we replaced *Perceived Usefulness* and *Perceived Ease of Use* with the UTAUT's expectancy constructs *Performance Expectancy* and *Effort Expectancy*. These encompass similar constructs from several other established acceptance theories [32].

Finally, we added *Social Influence* and *Facilitating Conditions* as additional constructs to our model. *Social Influence* and related constructs are contained in the newer TAM versions and many other models [24, 25, 30-32]. It seems reasonable that firefighters' beliefs will be influenced by their colleagues' opinions as well since they typically are committed team players. Prior studies also found a high degree of resistance to change in the firefighter domain, which might at least partly stem from the *Social Influence* of conservative colleagues [6]. *Facilitating Conditions* and related constructs are featured in several established models, as well [24, 27, 32]. We assume connections from *Facilitating Conditions* to *Intention* and to *Use* as it was established by the UTAUT2. The connections were motivated by the specific area of application and the fact that "*facilitation in the environment that is available to each consumer can vary significantly*" [33]. A high degree of variance also is typical for the German firefighter domain as the firefighting service is assigned to the communal level. The concrete *Facilitating Conditions* can vary considerably from city to city and will probably influence both a firefighter's actual system *Use* and his/her initial *Intention* to use it.

Regarding the left-hand part of our acceptance model, we adopted the basic structure of Wixom and Todd with *Information Quality*, *Information Satisfaction*, *System Quality*, and *System Satisfaction* [36]. As regards the antecedents of the two *Quality* constructs, we took over the existing constructs from the original model, like *Accuracy*, *Completeness*, *Reliability,* etc. Those constructs represent a best-practice collection in the user satisfaction literature for information technologies in general [35]. Besides that, we introduced additional constructs to represent specific factors that are relevant in the firefighter domain. Based on our analysis of related work, we found that especially three factors were not yet adequately represented in the model [6]: *Parsimony*, *Compactness*, and *Simplicity*. Based on the definition of these factors, *Parsimony* was added as an antecedent of *Information Quality*, *Compactness* and *Simplicity* as antecedents of *System Quality*. To link the two model parts, we connected *Information Satisfaction* and *System Satisfaction* to *Performance Expectancy* and *Effort Expectancy*. As defined by Venkatesh et al., the UTAUT's expectancy constructs correspond to the TAM's *Perceived Usefulness* and *Perceived Ease of Use* constructs [32]. In the original model of Wixom and Todd, *Information Satisfaction* and *System Satisfaction* were interpreted as object-based attitudes and treated as external variables for the before-mentioned TAM constructs [36]. Analogously, we assume the satisfaction constructs to be antecedents of the UTAUT's expectancy constructs.

For all constructs, we included multiple survey items to form a corresponding measurement instrument. Most of the items were adopted from established instruments but had to be rephrased to fit into the domain-specific context. Additional items for existing constructs, as well as the items for the newly introduced constructs, were formulated based on findings of related work [6]. Due to page limitations, we do not display the initial list of items. Instead, we only present the final list after describing the refinement steps that led toward it.

B. Pre-Test and Pilot-Study

The first step to refine our initial acceptance model and instrument was a pre-test [8, 9]. To include feedback from various perspectives, we consulted experts from different domains. To represent the academic information systems perspective, we interviewed two senior researchers from that field. To represent the information systems practitioner perspective, we consulted two developers and managers of a leading ERIS provider in Germany. To cover the academic firefighter perspective, two instructors of a state firefighting academy were consulted. Finally, we interviewed four firefighters of professional and voluntary fire departments to also include the perspective of firefighter practitioners. The experts were asked to complete the instrument and make suggestions for its improvement. Concretely, they were asked to assess the format, content, understandability, terminology, and completion effort. Furthermore, they were asked to name items that should be added or removed or assigned to different or additional constructs. The experts' feedback was analyzed by the research team and used to adjust both the acceptance model and the instrument. Most notably, we added *Mobility* as an additional construct since it was suggested by multiple experts.

As a second refinement step, we conducted a pilot-study to receive feedback from members of the final survey population [8, 9]. In our case, the population consisted of German firefighters. As pilot-testers, we acquired participants of several firefighting and command courses at a state firefighting academy. These courses are attended by firefighters from different regions and from all kinds of fire departments, ranging from small to large and from voluntary to professional departments. By including different types of courses, we were able to consider firefighters from all command levels. Like in the pre-test, the participants were asked to fill out the instrument. Afterwards, they were asked to provide feedback on experienced difficulties and missing or unnecessary items. All in all, we received feedback from 72 respondents. The results of the pilot-study showed support for our acceptance model. Amongst others, Cronbach's Alphas were above 0.70 for most of the constructs, which is seen as appropriate for early stages of research [56]. Also, many paths between the constructs showed significant correlations. The feedback was again used to further refine the instrument. The resulting final list of items is summarized in Table 3 (see Appendix). In the Source column, we indicate if the respective item originates from literature (references) or from the pre-test ("pre").

C. Final Instrument

After completing the refinement steps, we defined the final instrument and implemented it as an online survey. At the beginning of the survey, we described its goal, defined the term ERIS, stated the target population of firefighters knowledgeable of ERIS, and gave editing instructions. The survey itself consisted of four parts. In the first part, we asked if the respondents use an ERIS in emergency operations and how frequently and to which extent they do so. Furthermore, the respondents had to identify the particular ERIS they were referring to during the survey. For this purpose, we provided a list of popular ERIS in Germany. All listed ERIS offered comparable sets of basic features to fulfill the applying legal regulations [14] and were in the same evolutionary stage (see section II.A). As the evaluated acceptance factors are generic in nature and hence should apply to all ERIS, we deem the heterogeneity of the sample regarding the used systems to not produce severe adverse effects [36, 54]. In the second part, we presented the instrument items in randomized order. Each item had to be rated on a seven-point Likert scale ranging from "*do not agree at all*" to "*totally agree*". In the third part, we collected demographic information of our participants like gender, age, experience as a firefighter in years, amount of firefighting operations, command level, and the type of department they work in. Following the suggestions of multiple experts from the pre-test, the last part of the survey covered practical aspects. For instance, the respondents were asked to rate common features of ERIS regarding their perceived importance and to state if their department is planning to purchase or replace an ERIS. The survey invitation was disseminated using mailing lists and newsletters of the German Firefighter Association. In addition, we asked for participation in an expert forum and other appropriate social networks.

IV. RESULTS

Overall, 228 firefighters completed our survey. Because of missing values or other response anomalies, we had to exclude 16 responses, resulting in a sample of 212 participants. On average, they were 40 years old, were members of a fire department for 24 years and responded to approximately 94 emergency operations per year. 98% of the participants were male. 28% belonged to the operational command level (squad leaders and below), 27% to the tactical command level (platoon leaders), and 42% to the strategic command level (above platoon leaders). 90% worked at voluntary, 14% at professional, 6% at plant fire departments, and 6% were instructors at a firefighting academy (note that some firefighters stated to work for multiple institutions). Their departments conducted 1,315 annual operations on average.

To increase the validity of our results and account for confounding effects, we included some demographic information as control variables into our analysis. As advised in the literature, we particularly included the participants' current job role (command level) and their experience as control variables [3]. We then applied the partial least squares structural equation modeling technique (PLS-SEM) with SmartPLS 3 [57] to analyze our model. We did so for several reasons. In contrast to covariance-based approaches, PLS-SEM is especially suited for highly complex models, smaller sample sizes, and exploratory research with the goal of predicting key driver constructs [58-60]. While these characteristics match well with the study at hand, the size of our sample is still larger than "*10 times the largest number of structural paths directed at a particular construct in the structural model*", which is required to use PLS-SEM [60]. Following the guidelines of Hair, et al. [60], we employed bootstrapping in the bias-corrected and accelerated version with 5,000 samples and two-tailed testing with a 0.05 significance level to calculate the significances of our results. In the following, we separately describe the measurement model assessment and the structural model analysis. Finally, we present the results of the survey with respect to the practical aspects of ERIS.

A. Measurement Model Assessment

The measurement model assessment focuses on the relationships between the items and the constructs they are assigned to. First, we evaluated the internal consistency reliability of each construct by determining the Cronbach's Alpha and Composite Reliability. As shown in Table 1, the results lie well above the lower threshold of 0.70 for all constructs [56]. Only the Composite Reliabilities of *System Quality*, *System Satisfaction* and *Effort Expectancy* slightly exceed the upper threshold of 0.95 while Cronbach's Alphas lie well below it. As the internal consistency reliability typically lies between the tendentially underestimating Cronbach's Alpha and the overestimating Composite Reliability [60], the results are within the desired range. As a second criterion, we investigated the convergent validity. Convergent validity is established if the outer loadings of all items are significant and above 0.708. Furthermore, every construct's average variance extracted (AVE) is supposed to lie above 0.5 [61]. As shown in Table 3 (see Appendix), the outer loadings of all items are significant. However, the loadings of two *Facilitating Conditions* items were below 0.708. We therefore further examined these two items. Among others, we tested a segmentation of the construct into *Organizational* and *Technological Facilitating Conditions*. Since this did not deliver a significant improvement, we dropped the two items from the instrument [60]. Table 1 shows that the AVE values of the remaining constructs lie well above the threshold of 0.5.

TABLE 1. MEASUREMENT MODEL RESULTS

Construct	Internal Consistency		Convergent Validity
	Cronbach's Alpha	Composite Reliability	Average Variance Extracted (AVE)
Format	0.906	0.941	0.842
Completeness	0.802	0.884	0.719
Currency	0.836	0.901	0.753
Accuracy	0.854	0.911	0.774
Parsimony	0.751	0.859	0.671
Information Quality	0.888	0.931	0.818
Information Satisfaction	0.859	0.934	0.877
Flexibility	0.831	0.899	0.748
Reliability	0.865	0.917	0.788
Timeliness	0.870	0.920	0.794
Integration	0.834	0.900	0.751
Accessibility	0.836	0.901	0.753
Compactness	0.888	0.930	0.817
Simplicity	0.878	0.924	0.803
Mobility	0.788	0.876	0.703
System Quality	0.924	0.952	0.868
System Satisfaction	0.905	0.955	0.913
Performance Expectancy	0.894	0.934	0.825
Effort Expectancy	0.925	0.952	0.870
Social Influence	0.852	0.910	0.771
Facilitating Conditions	0.833	0.889	0.668
Behavioral Intention	0.916	0.947	0.856

Lastly, we examined the discriminant validity. On the item level, it is established if all items have higher loadings on the construct they are assigned to than on any other construct [60]. On the construct level, it is established if the square root of each construct's AVE is greater than its correlation with all other constructs [58]. As Table 4 and Table 5 (see Appendix) show, the results satisfy the criteria on both item and construct level. Taken together, our measurement model fulfills the criteria given to establish internal consistency reliability, convergent validity, and discriminant validity.

B. Structural Model Evaluation

After assessing the measurement model, we examined the relationships in the structural model. In a first step, we ruled out collinearity issues by analyzing the variance inflation factors (VIF). As shown in Table 6 (see Appendix), the VIFs for all paths of our model except one are below the recommended threshold of 5 [60]. Since the VIF between *Timeliness* and *System Satisfaction* is 5.13, we examined this part of the model in more detail. Deleting *Timeliness* from the model increases both the coefficient and the significance of the path from *Reliability* to *System Quality*. However, it reduces *System Quality*'s R^2. Therefore, and because *Timeliness* is an important factor from a theoretical perspective, we decided to keep it in the model.

The results of the model analysis are shown in Fig. 2. With respect to the main model, nine of the 13 antecedents of the *Quality* constructs show significant relationships. Surprisingly, the path from *Compactness* is significantly negative. The paths between the *Quality*, *Satisfaction*, and *Expectancy* constructs all show sufficient coefficients and significances. The path from *Facilitating Conditions* to *Behavioral Intention* is the only one in the right-hand part of our model that is not significant. Altogether, the results support most of the hypothesized relationships. The path coefficients of the control variables and their significance levels can be seen in Table 7 (see Appendix). None of the control variables had a significant effect on any latent variable. As including them enhanced the R^2 values and hence the model quality, we kept them in the model.

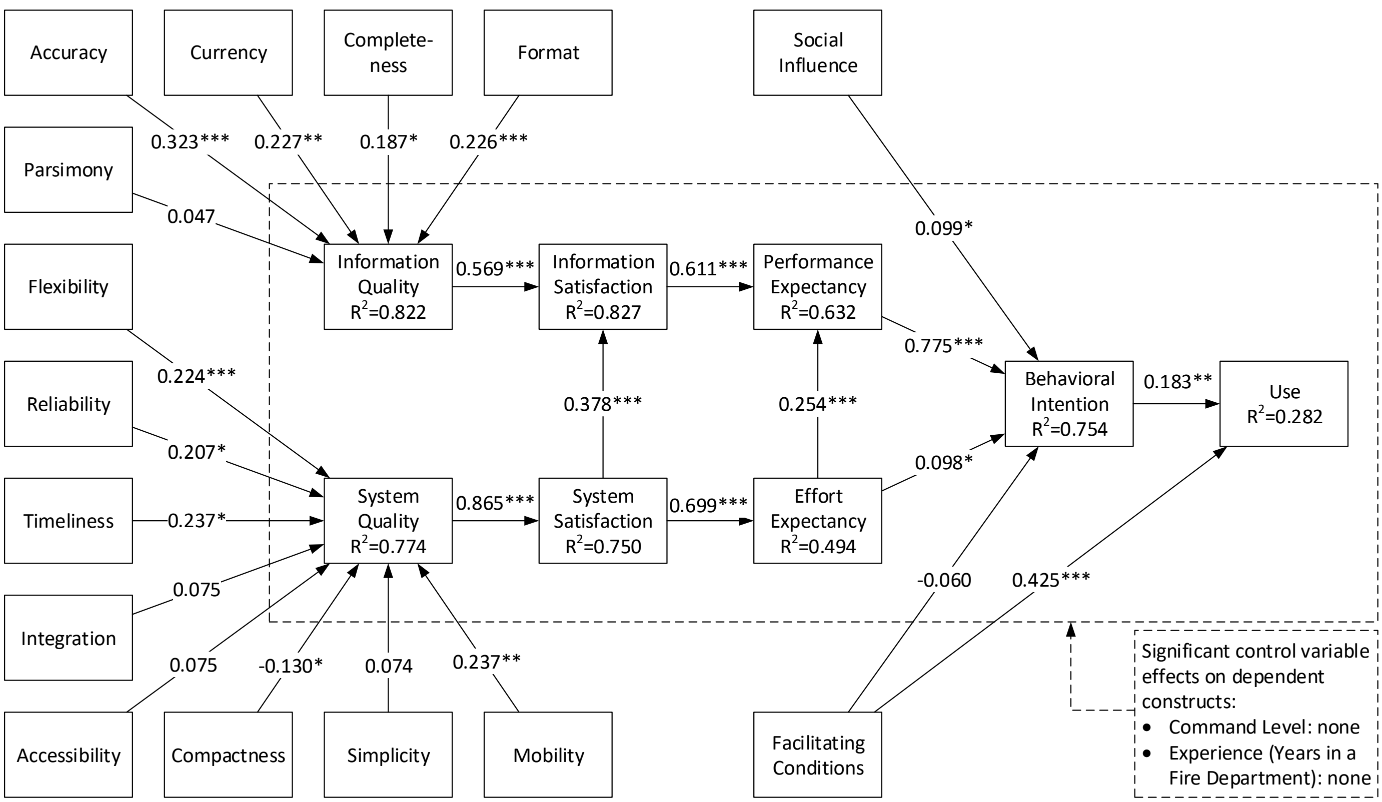

Fig. 2. Structural Model Results. Legend: *: p < 0.05; **: p < 0.01; ***: p < 0.001

Regarding our model's predictive power, we display the coefficients of determination (R^2) for all endogenous constructs in Fig. 2. Roughly, an R^2 above 0.75, 0.50, and 0.25 can respectively be interpreted as substantial, moderate, and weak predictive power [60]. As the results indicate, our model exhibits substantial predictive power for the *Quality* and *Satisfaction* constructs as well as for *Behavioral Intention*. The *Expectancy* constructs are predicted with moderate strength while the actual system use is predicted only weakly.

We additionally calculated the effect sizes (f^2) of all paths in the model. As a rule of thumb, f^2 values above 0.35, 0.15, and 0.02 represent large, medium, and small effects [62]. As can be seen in Table 6 (see Appendix), all significant paths of the model show at least a weak effect size above 0.02. Large effects can be observed on the paths from *Information Quality* to *Information Satisfaction* to *Performance Expectancy* to *Behavioral Intention* and from *System Quality* to *System Satisfaction* to *Effort Expectancy*.

To assess the model's out-of-sample predictive power, we calculated the predictive relevance (Q^2). It is determined by employing blindfolding, in which – in our case – every seventh observation of the sample is omitted from the calculations. After seven calculation runs, every observation has been omitted once. Whenever Q^2 exceeds 0, the model has a generalizable predictive relevance for the respective endogenous construct [63]. As displayed in Table 6 (see Appendix), this is the case for all our constructs.

C. Device and Feature Expectations

136 of the 212 participants agreed to answer an additional survey part with questions regarding practical aspects such as the preferred devices and desired features. First, they were shown a list of eleven different ERIS that are currently available on the market. On average, the participants stated to know 2.6 of these systems. Fireboard [13] was known by 76% of the participants while TecBOS.Command [12] was known by 34% and CommandX [10] by 33%. The best-informed respondent knew nine of the eleven systems. In addition, 25% of the participants stated that their department is planning to purchase a new or replace an existing ERIS either in a short (10%), medium (7%), or long term (8%).

Regarding the preferred devices, most participants wanted to use ERIS on a desktop PC (93%), a notebook (96%), or a tablet computer (87%). Only 30% viewed smartphones as devices that should be supported by an ERIS. The systems should consequently offer a certain level of mobility, but obviously do not necessarily have to be optimized for small devices. The respondents were also asked to rate the importance of 16 common features. Each feature had to be rated on a seven-point scale ranging from 1 = "*not important at all*" to 7 =

"*very important*". As shown in Table 2, offline and multi-user functionalities, an operation log, and an overview of units and resources were found to be very important. Interfaces to other systems, situation maps, messaging functionality, and the ability to store additional plans were moreover viewed as important.

TABLE 2. IMPORTANCE OF FEATURES (rated on a scale from 1 = "not important at all" to 7 = "very important")

Feature	Mean	SD
Offline Functionality	6.74	0.55
Operation Log	6.60	0.86
Multi-User Functionality	6.54	0.92
Resource Overview	6.49	0.78
Situational Map	6.21	1.17
Messaging Functionality	5.91	1.46
Pre-Planning of Operations	5.54	1.27
Customizing Functionality	4.48	1.68
Interface for Alarm Information	6.00	1.22
Interface for Unit Statuses	5.82	1.34
Interface to the Control Center	5.74	1.39
Other Interfaces	5.32	1.35
Storing of Fire/Operation Plans	6.13	1.17
Storing of Hydrant Plans	5.85	1.32
Storing of HAZMAT Information	5.30	1.69
Storing of other Plans or Guides	5.48	1.53

The participants had the opportunity to describe additional features that they perceive as essential. The most common responses specified precise system requirements regarding *Flexibility*, *Reliability*, and *Mobility*, which are included as generic attributes in the acceptance model. For instance, the hardware running the ERIS should be "*backed up by an emergency power supply*", and the incident commander should be able to "*access the most important data on his tablet*" anywhere. Regarding the processed information, the most desired feature was the integration of GPS data to "*display the position of units on the situational map*". In the acceptance model, most of the features desired with respect to the processed information are reflected by the factors *Accuracy*, *Currency*, and *Completeness*. Another common response was that the ERIS should "*use standardized protocols*" or have "*appropriate interfaces*" to systems of other fire departments or government organizations. Finally, low or reasonable costs have been frequently stated as an important requirement.

V. DISCUSSION

In the following section, we discuss and interpret the previously described results of our study. To gain deeper insights, we also link the measurement and structural model results to the practitioners' practical device and feature expectations. Furthermore, we elaborate on academical and practical implications that can be derived from our findings as well as the limitations pertinent to our study.

A. Factors Determining the Acceptance of an ERIS

Information Quality is very well predicted by the constructs contained in the acceptance model (R^2=82%). The most significant determinants turned out to be the *Accuracy*, *Format*, and *Currency* of information, which seems reasonable considering the usage context. In time-critical situations with lives at stake, firefighters demand accurate and current information that is displayed in an understandable way. Another significant factor is *Completeness*, whereas *Parsimony* was insignificant. Obviously, firefighters seem to tolerate a certain amount of unnecessary information in an ERIS as long as none of the required information is missing. Accordingly, none of the features typically provided by an ERIS was found to be omittable (see Table 2). Future generations of ERIS should therefore utilize more rather than less information. A way to better address many of the *Information Quality* determinants may be a transitioning to the second evolution stage (see section II.A) and to leverage sensor data [16-19]. For instance, the participants stated that the inclusion of GPS positions in the situational map can lead to more accurate, current, and complete information. The results of our survey indicate that the practitioners seem to be ready for such an evolution.

System Quality is also very well predicted by the constructs contained in the model (R^2=77%). Its most significant determinants are *Flexibility*, *Reliability*, *Timeliness*, and *Mobility* of the ERIS. Considering the domain and the participants' qualitative feedback, the importance of those determinants seems reasonable as well. The fact that each emergency is unique must be considered by an ERIS, which needs to support a certain degree of flexibility in its use. In time-critical situations, the system furthermore must not delay the operation and must not fail in any case. Features like the implementation of offline functionality and an emergency power supply were hence explicitly demanded by the participants. The *Mobility* construct was only added to the model based on the feedback obtained during the pre-test, but ultimately proofed to be indeed a significant determinant of system quality. The fact that 87% of the participants desire an ERIS, which is available on a tablet computer, additionally underlines the importance of this topic. The *Integration*, *Accessibility*, and

Simplicity of an ERIS also have a positive, yet comparably smaller effect on the perceived system quality. While these factors hence seem to determine System Quality rather circumstantially, *Compactness* turned out to have a negative effect. In contrast to our initial assumption, firefighters thus seem to prefer extensive rather than compact systems. This finding seems to be corroborated by a study that found large displays to be effective in supporting incident commanders [64]. As ERIS will likely be used in command vehicles to a large part, optimizing them for small devices like smartphones hence rather seems to be counterproductive.

Determined by the *Quality* constructs, the *Satisfaction* constructs are also very well predicted by our acceptance model (R^2=83 and 75%). However, it has a slightly lower predictive power regarding the subsequent *Expectancy* constructs (R^2=63 and 49%). Hence, there must also exist further determinants that have not yet been considered. The answers to the open questions point to some additional factors that might be relevant. Some respondents mentioned the service of the ERIS providers, which could be covered by the *Service Quality* construct from the user satisfaction literature [34]. Some participants moreover stated their ERIS is fun to work with. This might be reflected by the *Perceived Enjoyment* construct from the technology acceptance literature [31]. The inclusion of such constructs might further increase the model's predictive power. However, as it would also increase its complexity, we only plead for modest, goal-driven extensions.

Regarding the model's right-hand part, the firefighters' *Behavioral Intention* to use an ERIS is substantially well predicted (R^2=75%). As proposed by the underlying theories, *Performance Expectancy* seems to be a suitable predictor construct in our context as well [29-32]. *Social Influence* and *Effort Expectancy* also show a significant, but smaller influence. In contrast to the theoretical expectations, however, the *Facilitating Conditions* do not seem to have a significant influence on the *Behavioral Intention*. The participants hence seem to determine their intention to use an ERIS independently from additional measures to facilitate its use. Nevertheless, the *Facilitating Conditions* still largely determine the actual system *Use*, on which they even have a higher influence than the *Behavioral Intention*. This observation implies that the intentions of individual firefighters are only one determinant that forms the actual usage decision. Even if the firefighters might acknowledge the potential of an ERIS, the use of such systems in practice can still be facilitated or hindered by other aspects that are out of the scope of this study. The actual *Use* can hence only be partially predicted by our acceptance model (R^2=28%). However, some answers to the open survey questions also name additional determinants that might be relevant for the usage decision determinants. The participants particularly highlighted the technical compatibility and costs. To represent compatibility considerations in our model, we originally had included two items into the *Facilitating Conditions* construct (see Table 3, Appendix). While we had to drop them from the instrument due to their poor convergent validity, it appears to be worthwhile to further explore such factors in future.

Altogether, the developed acceptance model seems to be well suited to explain firefighters' personal opinions and intentions to use ERIS. It covers the important perspective of the users and explains under which conditions they perceive ERIS as beneficial. Nevertheless, it can explain the actual usage of such systems only to some extent as the usage decision is influenced by other personal and organizational factors as well.

B. Implications for Academia

The findings gained in our study have implications for academia and practice. As regards academia, our findings enrich the research stream that investigates the acceptance of information technologies and systems. In this context, neither the acceptance of information technologies by firefighters nor the acceptance of ERIS in particular has been in the focus so far. As the results of our study show, the acceptance of information technologies in the firefighter domain also seems to be determined by several domain-specific factors, which resemble the existing tight usage constraints. As existing acceptance theories do not adequately consider these usage constraints, they are not well suited to explain the acceptance of FITs. The presented, domain-specific acceptance model contributes to achieving an in-depth understanding why firefighters accept or reject ERIS. By considering well-established generic as well as specific factors, it provides a unique overview of the circumstances that influence firefighters' intention to use an ERIS. The results of the conducted quantitative evaluation additionally provide insights into the significance and the comparative importance of the identified factors. While the acceptance model has been developed specifically to explain the acceptance of ERIS, we assume that the identified factors could also provide a more refined theoretical basis to understand the acceptance of other FITs, thus providing better support for their ongoing development.

With the presented acceptance model, we furthermore combine findings from the user satisfaction and the technology acceptance literature. In so doing, we answer a call to more closely "*examine the influence of design characteristics on user acceptance*" [31]. The results of our study do not only show that information and system characteristics of ERIS are important determinants for the acceptance of these systems. Building upon and confirming the work of Wixom and Todd, we also demonstrate how recent findings in the user satisfaction and technology acceptance domains can be brought together to form a holistic theoretical foundation that explains the acceptance of information technologies and systems in general.

C. Implications for Practice

The findings of our study are also relevant for practice. In particular, the identified acceptance factors have numerous implications for the design of ERIS, which ought to account for existing usage constraints and user requirements in the best possible way. From the results of our quantitative study, we can infer that the information provided by ERIS must be presented in a straightforwardly understandable *Format*. In addition, it needs to be *accurate*, *current*, and *complete*. According to the study results, the system itself should moreover be designed in a way that ensures its *Flexibility*, *Mobility*, *Reliability*, and the *Timeliness* of its operations. At the same time, a system design that overly emphasizes *Compactness* (e.g., to run on a smartphone) was rejected by the prospective users. The before-mentioned design implications are primarily relevant for the developers of ERIS, who should optimize their systems to fulfill the identified user requirements in the best possible manner. The developers of ERIS could also consider implementing the specific device and feature requirements that we have gathered in the open survey part. Regarding the developers of ERIS, the study results can hence provide a basis to make better-informed design decisions and thus help to facilitate the development of ERIS that eventually meet the practitioners' needs.

Basically, however, the identified design requirements can also serve as a benchmark to evaluate the suitability of currently available ERIS. Accordingly, the procurers of ERIS can benefit from the findings of our study as well. In future research endeavors, even currently still quite abstract constructs like *Accuracy* or *Reliability* can be further refined, thus leading to a catalog of requirements that allows procurers to objectively evaluate ERIS and choose a suitable product for their fire department. Ultimately, the results of our study should also affect firefighters as the actual users of ERIS. In line with the situation awareness theory, we expect that firefighters' decision-making abilities are largely determined by the availability of suitable information [4, 5]. As ERIS, which adequately reflect existing usage constraints and fulfill the identified user requirements, should provide a better information base, the findings of our study should contribute to further improving firefighters' decision-making and, consequently, to increasing their efficacy on site.

D. Limitations

We have taken various precautions to ensure the validity of our results. During a pre-test, we conducted interviews with ten experts who brought in different perspectives on the subject matter. In addition, we conducted a pilot-study with 72 participants. In both stages, we used the results to refine the acceptance model and the corresponding instrument. Nevertheless, there exist several limitations, in the light of which the presented results ought to be interpreted. First, the sample size obtained during the final survey still is comparably small as we only included participants that had a firefighter background and experiences with ERIS. In so doing, we could gain realistic feedback about the use of particular systems in practice. Second, we limited our analysis to German firefighters. While we tried to control for regional and other differences within the country by including participants from all over Germany with varying experience levels and from different types of fire departments, the results may not be straightforwardly transferable to other countries. The main reason for this is that the response processes and the organizational structures might differ in other countries. Accordingly, we expect that some aspects might be more or less important in other countries. As the existing usage constraints during emergency responses appear to be largely comparable, however, we believe that the provided model will also be usable to explore the acceptance of ERIS on a global scale. Third, we were not able to ensure that all participants were in the exact same phase of implementing their ERIS. A longitudinal study of acceptance factors might hence provide further insights into the acceptance of ERIS, since user perceptions might change with the prolonged use of an information technology or system.

VI. Conclusion

To explain the acceptance of ERIS, we presented a new acceptance model. Next to generic factors, it contains several domain-specific factors that determine a firefighter's intention to use an ERIS and the actual system usage. We found that firefighters' intention to use an ERIS is determined by several factors that characterize the quality of the system and that of the provided information. In particular, the flexibility, reliability, timeliness, and mobility of the system itself, as well as the accuracy, format, and currency of the provided information turned out to be important acceptance factors. From an academic perspective, the new acceptance model extends existing general-purpose acceptance theories and provides a domain-specific lens of analysis that might also be used to explain the acceptance of other novel FITs. For practice, the results of our study yield several design implications, which can guide the development of ERIS and be used as a benchmark to evaluate existing approaches. We therefore hope that the results of our study can help to better transfer the so far mostly theoretical benefits of ERIS into practical applications and to facilitate the development of systems, which are closely aligned to the users' needs.

However, the results of our study also provide several avenues for future research. So far, the acceptance and usage of information technologies in emergency domains has been investigated only sporadically. With respect to the presented findings, future research endeavors could, for instance, test the presented acceptance model in an international setting. To examine the generalizability of the presented acceptance model, future research could also explore if it is suitable to explain the acceptance of other FITs like drones, on-ground robots, or intelligent protective clothing. With the presented acceptance model and the measurement instrument, we also hope to provide a starting point for such endeavors.

APPENDIX

TABLE 3. SURVEY ITEMS, DESCRIPTIVE STATISTICS, OUTER LOADINGS (*p < 0.05; **p < 0.01; ***p < 0.001; RC = reverse coded)

Construct	Item	Source	Mean	SD	Loading
Format	The information provided by the ERIS is well formatted.	[6, 36]	5.155	1.349	0.912***
	The information provided by the ERIS is well laid out.	[6, 36]	5.243	1.292	0.927***
	The information provided by the ERIS is clearly presented.	[6, 36]	5.313	1.406	0.913***
Completeness	The ERIS enables me to capture a complete set of information.	[6, 36]	5.466	1.300	0.885***
	The ERIS produces and documents comprehensive information.	[6, 36]	5.986	1.093	0.769***
	The ERIS enables me to process all the information I need.	[6, 36]	5.327	1.311	0.884***
Currency	The ERIS provides me with the most recent information about the current mission.	[36]	5.263	1.377	0.859***
	The ERIS enables me to process the most current information.	[36]	5.716	1.218	0.877***
	The ERIS provides me with a recent overview of the mission situation.	[36]	5.687	1.316	0.868***
Accuracy	The ERIS produces correct information.	[6, 36]	5.435	1.201	0.890***
	The ERIS enables me to process information precisely.	[6, 36]	4.822	1.478	0.853***
	The information provided by the ERIS is accurate.	[6, 36]	5.406	1.171	0.896***
Parsimony	The ERIS provides me much needless information. (RC)	[6]	4.612	1.405	0.712***
	The ERIS does not provide me any unnecessary information.	[6]	4.552	1.490	0.861***
	The ERIs provides me only the information I need.	[6]	4.459	1.518	0.874***
Information Quality	Overall, I would give the information from the ERIS high marks.	[36]	5.636	1.171	0.914***
	In terms of information quality, I would rate the ERIS highly.	[36]	5.462	1.204	0.920***
	In general, the ERIS provides me with high-quality information.	[36]	5.464	1.250	0.879***
Information Satisfaction	Overall the information I get from the ERIS is very satisfying.	[36]	5.405	1.321	0.932***
	I am very satisfied with the information I receive from the ERIS.	[36]	5.416	1.292	0.941***
Flexibility	The ERIS can be adapted to meet a variety of mission situations.	[6, 36]	5.565	1.382	0.859***
	The ERIS can be flexibly adjusted to new demands or conditions.	[6, 36]	4.787	1.543	0.893***
	The ERIS is versatile in addressing needs as they arise.	[6, 36]	4.770	1.557	0.842***
Reliability	The ERIS operates reliably.	[6, 36]	5.392	1.400	0.925***
	The ERIS performs dependably.	[6, 36]	5.286	1.404	0.928***
	The ERIS is fail safe.	[6, 36]	4.034	1.730	0.804***
Timeliness	The ERIS reacts to my requests quickly.	[6, 36]	5.629	1.304	0.882***
	The ERIS provides information in a timely fashion.	[6, 36]	5.290	1.233	0.880***
	The ERIS can be operated smoothly.	[6, 36]	5.310	1.406	0.911***
Integration	The ERIS enables me to link data from different sources.	[36]	5.121	1.535	0.881***
	The ERIS pulls together information that used to come from different sources.	[36]	5.450	1.282	0.839***
	The ERIS effectively combines data from different sources.	[36]	5.113	1.456	0.878***
Accessibility	The ERIS makes information very accessible.	[36]	5.626	1.227	0.860***
	The ERIS makes information easy to access.	[36]	5.493	1.233	0.892***
	The ERIS makes information accessible at all times.	[36]	5.524	1.319	0.850***
Compactness	The space requirements of the ERIS are low.	[6]	5.426	1.446	0.908***
	The ERIS is space-saving.	[6]	5.325	1.509	0.918***
	The ERIS can be used in narrow spaces.	[6]	5.507	1.398	0.886***
Simplicity	The ERIS has a simple structure.	[6]	4.976	1.554	0.927***
	The ERIS can be used Intuitively.	[6]	4.809	1.695	0.926***
	The ERIS is structured complicatedly. (RC)	[6]	4.649	1.588	0.832***
Mobility	The ERIS is suitable for the mobile application.	Pre	5.729	1.379	0.875***
	The ERIS is easy to transport.	Pre	5.372	1.689	0.811***
	The ERIS can be used at various locations.	Pre	5.948	1.217	0.827***
System Quality	In terms of system quality, I would rate the ERIS highly.	[36]	5.362	1.417	0.930***
	Overall, the ERIS is of high quality.	[36]	5.493	1.358	0.941***
	Overall, I would give the quality of the ERIS a high rating.	[36]	5.476	1.369	0.924***
System Satisfaction	All things considered, I am very satisfied with the ERIS.	[36]	5.379	1.521	0.956***
	Overall, my Interaction with the ERIS is very satisfying.	[36]	5.291	1.452	0.955***
Performance Expectancy	I would find the ERIS useful in my work.	[24, 28, 32]	5.743	1.317	0.906***
	Using the ERIS enables me to accomplish tasks more quickly.	[24, 28, 32]	5.327	1.487	0.900***
	Using the ERIS improves the quality of the work I do.	[24]	5.521	1.357	0.919***
Effort Expectancy	I would find the ERIS easy to use.	[24, 28, 32]	5.090	1.623	0.930***
	It would be easy for me to become skillful at using the ERIS.	[28, 32]	5.295	1.558	0.945***
	Learning to operate the ERIS would be easy for me.	[24, 28, 32]	5.399	1.434	0.923***
Social Influence	Colleagues of my fire department think that using the ERIS is wise.	[28, 32]	5.200	1.366	0.863***
	Colleagues of other fire departments think that using the ERIS is wise.	[28, 32]	5.182	1.370	0.901***
	Colleagues of other organizations think that using the ERIS is wise.	[28, 32]	5.410	1.319	0.869***
Facilitating Conditions	In my dept., a specific person or group is available for assistance with system difficulties.	[25, 32]	5.320	1.834	0.856***
	In my department, a specific person or group is available for assistance with using the ERIS.	[25, 32]	5.515	1.819	0.838***
	In my department, there are rules on how to apply the ERIS.	Pre	4.468	2.010	0.724***
	The ERIS is integrated into the command organization of my department.	Pre	4.950	1.929	0.844***
(dropped items)	The ERIS is not compatible with other systems I use. (RC)	[27, 32]	3.929	1.752	0.190**
	The ERIS is compatible with systems used by other fire dept. and organizations I work with.	[27, 32]	4.309	1.781	0.282***
Behavioral Intention	Generally, I Intend to use the ERIS.	[32]	6.038	1.170	0.936***
	Given that I had the possibility, I predict that I would use the ERIS.	[30]	5.886	1.362	0.919***
	Assuming I had access to the ERIS, I Intend to use it.	[30]	6.067	1.252	0.919***

TABLE 4. DISCRIMINANT VALIDITY ON ITEM LEVEL (LOADINGS- / CROSS-LOADINGS-MATRIX)

Construct	Item	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
1 Format	1	**.91**	.68	.70	.69	.62	.75	.76	.73	.66	.70	.57	.69	.50	.66	.54	.74	.71	.57	.58	.46	.40	.49	.28
	2	**.93**	.72	.70	.66	.57	.75	.78	.71	.69	.74	.55	.68	.46	.70	.58	.78	.78	.63	.65	.40	.41	.57	.35
	3	**.91**	.66	.67	.66	.52	.71	.73	.70	.61	.69	.55	.71	.55	.68	.51	.73	.76	.62	.63	.39	.35	.53	.34
2 Completeness	1	.67	**.88**	.75	.69	.57	.72	.76	.72	.69	.72	.57	.71	.49	.58	.53	.72	.69	.64	.53	.40	.41	.51	.31
	2	.53	**.77**	.61	.56	.42	.62	.63	.48	.47	.55	.47	.59	.28	.43	.42	.55	.60	.60	.43	.30	.39	.58	.25
	3	.70	**.88**	.71	.68	.54	.73	.72	.78	.65	.68	.60	.70	.49	.62	.58	.71	.72	.64	.57	.47	.36	.58	.29
3 Currency	1	.58	.66	**.86**	.63	.57	.66	.62	.58	.59	.63	.55	.60	.51	.51	.47	.59	.57	.59	.41	.44	.45	.52	.25
	2	.68	.73	**.88**	.65	.53	.77	.77	.68	.69	.75	.58	.74	.55	.61	.56	.71	.70	.69	.57	.47	.38	.63	.20
	3	.70	.73	**.87**	.69	.51	.71	.69	.65	.61	.67	.49	.65	.41	.57	.44	.68	.68	.65	.53	.38	.34	.59	.24
4 Accuracy	1	.69	.70	.69	**.89**	.57	.76	.74	.61	.67	.67	.54	.68	.53	.58	.57	.69	.67	.63	.56	.40	.35	.57	.24
	2	.62	.68	.65	**.85**	.63	.68	.65	.64	.67	.67	.55	.63	.47	.60	.47	.60	.67	.66	.54	.38	.33	.59	.40
	3	.62	.63	.66	**.90**	.53	.76	.70	.59	.66	.66	.59	.67	.51	.50	.51	.65	.63	.60	.49	.38	.40	.52	.28
5 Parsimony	1	.41	.43	.44	.46	**.71**	.47	.45	.41	.46	.44	.41	.37	.28	.45	.25	.39	.39	.44	.36	.36	.24	.40	.24
	2	.55	.53	.54	.54	**.86**	.55	.55	.47	.48	.54	.37	.47	.31	.44	.28	.50	.53	.44	.39	.39	.28	.42	.29
	3	.56	.52	.53	.59	**.87**	.58	.55	.50	.57	.56	.39	.49	.38	.51	.32	.50	.55	.51	.50	.38	.31	.48	.35
6 Information Quality	1	.78	.77	.78	.75	.62	**.91**	.83	.71	.71	.72	.68	.75	.49	.59	.56	.81	.80	.71	.53	.54	.44	.67	.31
	3	.72	.73	.76	.75	.59	**.92**	.81	.67	.69	.72	.63	.74	.53	.56	.59	.77	.76	.69	.53	.50	.43	.62	.33
	2	.67	.71	.69	.77	.56	**.88**	.77	.65	.69	.71	.66	.76	.55	.59	.57	.70	.71	.72	.59	.40	.36	.64	.22
7 Information Satisfaction	1	.75	.76	.74	.73	.56	.81	**.93**	.70	.70	.76	.60	.74	.55	.58	.57	.77	.78	.69	.55	.47	.42	.61	.32
	2	.80	.79	.77	.76	.63	.85	**.94**	.72	.72	.75	.61	.77	.49	.65	.58	.81	.82	.75	.62	.51	.44	.66	.35
8 Flexibility	1	.68	.70	.65	.58	.50	.66	.69	**.86**	.56	.58	.53	.60	.42	.49	.46	.68	.68	.56	.47	.41	.36	.50	.28
	2	.68	.65	.60	.61	.45	.62	.61	**.89**	.62	.59	.59	.62	.45	.55	.50	.65	.62	.51	.47	.39	.33	.46	.23
	3	.66	.69	.66	.62	.51	.67	.67	**.84**	.68	.64	.57	.68	.57	.64	.51	.61	.66	.63	.57	.41	.36	.59	.26
9 Reliability	1	.69	.70	.71	.70	.57	.72	.74	.69	**.92**	.80	.57	.71	.59	.70	.65	.76	.76	.68	.63	.39	.38	.65	.31
	2	.68	.70	.70	.71	.56	.73	.72	.67	**.93**	.80	.60	.72	.55	.68	.62	.76	.75	.64	.62	.40	.37	.56	.24
	3	.52	.49	.51	.60	.50	.59	.55	.54	**.80**	.58	.49	.54	.38	.52	.36	.56	.60	.56	.46	.36	.40	.52	.23
10 Timeliness	1	.67	.67	.73	.65	.52	.70	.70	.61	.72	**.88**	.54	.71	.58	.65	.55	.67	.70	.62	.61	.38	.38	.56	.26
	2	.64	.71	.71	.69	.58	.74	.72	.62	.70	**.88**	.56	.74	.54	.65	.52	.68	.70	.68	.62	.40	.48	.59	.30
	3	.76	.69	.68	.68	.58	.69	.73	.64	.79	**.91**	.50	.69	.56	.80	.60	.77	.77	.68	.76	.41	.46	.57	.34
11 Integration	1	.50	.55	.51	.57	.39	.59	.53	.57	.57	.51	**.88**	.57	.40	.45	.48	.57	.55	.52	.37	.33	.28	.42	.15
	2	.55	.57	.58	.57	.44	.67	.59	.54	.58	.55	**.84**	.61	.41	.49	.47	.58	.58	.57	.42	.33	.19	.48	.13
	3	.53	.56	.52	.51	.39	.63	.55	.58	.47	.48	**.88**	.54	.41	.43	.45	.53	.59	.51	.38	.36	.30	.46	.10
12 Accessibility	1	.67	.64	.62	.62	.41	.72	.70	.60	.61	.66	.60	**.86**	.52	.56	.55	.66	.66	.63	.51	.41	.38	.56	.23
	2	.69	.71	.72	.69	.53	.76	.72	.65	.67	.73	.62	**.89**	.50	.67	.55	.69	.74	.72	.66	.40	.40	.65	.28
	3	.61	.70	.66	.64	.48	.66	.67	.65	.67	.69	.50	**.85**	.52	.63	.50	.62	.58	.58	.59	.32	.35	.53	.20
13 Compactness	1	.48	.37	.44	.49	.33	.47	.46	.45	.51	.55	.36	.48	**.91**	.50	.57	.49	.50	.47	.47	.27	.15	.42	.25
	2	.52	.49	.53	.55	.39	.57	.52	.52	.55	.57	.48	.57	**.92**	.54	.65	.52	.55	.55	.50	.30	.29	.46	.25
	3	.49	.50	.56	.52	.36	.51	.52	.52	.52	.59	.43	.56	**.89**	.50	.64	.47	.48	.50	.50	.29	.30	.46	.23
14 Simplicity	1	.74	.65	.66	.65	.55	.66	.67	.62	.72	.78	.51	.70	.56	**.93**	.60	.70	.72	.65	.81	.36	.39	.60	.38
	2	.68	.63	.59	.60	.52	.61	.63	.64	.70	.74	.52	.69	.53	**.93**	.56	.69	.70	.65	.82	.41	.39	.61	.33
	3	.56	.42	.48	.43	.44	.43	.45	.44	.49	.59	.36	.51	.41	**.83**	.42	.52	.54	.46	.67	.21	.30	.41	.31
15 Mobility	1	.51	.49	.47	.51	.32	.52	.50	.46	.53	.55	.43	.48	.59	.48	**.88**	.57	.56	.46	.45	.34	.28	.40	.21
	2	.46	.47	.43	.46	.29	.48	.47	.47	.53	.50	.45	.46	.64	.49	**.81**	.53	.50	.42	.40	.25	.20	.39	.33
	3	.52	.54	.52	.51	.26	.59	.56	.50	.52	.54	.47	.59	.50	.52	**.83**	.62	.55	.47	.50	.29	.28	.44	.24
16 System Quality	1	.73	.70	.67	.65	.55	.75	.76	.71	.79	.74	.57	.68	.52	.65	.60	**.93**	.80	.66	.59	.52	.38	.59	.35
	2	.79	.75	.74	.73	.54	.81	.82	.71	.75	.77	.63	.76	.53	.69	.69	**.94**	.82	.70	.63	.43	.38	.62	.33
	3	.77	.75	.71	.67	.52	.79	.79	.69	.67	.71	.61	.67	.47	.67	.63	**.92**	.80	.66	.61	.50	.39	.63	.33
17 System Satisfaction	1	.78	.76	.70	.71	.57	.79	.82	.73	.76	.77	.62	.73	.52	.71	.63	.85	**.96**	.75	.66	.47	.40	.69	.38
	2	.79	.75	.73	.72	.59	.81	.82	.72	.76	.78	.64	.73	.56	.69	.59	.81	**.96**	.79	.68	.50	.49	.73	.39
18 Performance Expectancy	1	.63	.71	.69	.63	.49	.72	.73	.64	.63	.69	.59	.71	.49	.63	.54	.70	.77	**.91**	.60	.48	.49	.83	.43
	2	.61	.65	.69	.69	.52	.72	.69	.59	.67	.70	.58	.67	.54	.62	.44	.65	.72	**.90**	.60	.49	.47	.73	.36
	3	.56	.65	.66	.64	.53	.68	.68	.56	.64	.63	.51	.64	.50	.55	.47	.63	.70	**.92**	.53	.45	.43	.77	.39
19 Effort Expectancy	1	.68	.61	.58	.58	.48	.59	.62	.60	.67	.76	.46	.68	.54	.88	.54	.67	.71	.62	**.93**	.30	.39	.58	.32
	2	.63	.56	.55	.56	.50	.57	.59	.54	.60	.68	.40	.63	.50	.78	.49	.60	.68	.61	**.94**	.30	.41	.60	.35
	3	.58	.51	.50	.53	.45	.53	.53	.48	.54	.65	.40	.58	.48	.74	.49	.55	.55	.55	**.92**	.23	.37	.49	.29
20 Social Influence	1	.39	.43	.43	.37	.37	.46	.46	.41	.40	.40	.37	.39	.26	.33	.34	.46	.48	.49	.24	**.86**	.39	.49	.19
	2	.36	.34	.38	.37	.40	.43	.41	.38	.37	.35	.29	.33	.26	.30	.31	.41	.40	.41	.24	**.90**	.19	.40	.14
	3	.44	.45	.48	.41	.44	.51	.50	.43	.36	.42	.36	.41	.32	.35	.27	.48	.45	.46	.29	**.87**	.22	.45	.15
21 Facilitating Conditions	1	.38	.39	.36	.39	.29	.42	.41	.36	.39	.44	.28	.39	.25	.34	.26	.38	.41	.43	.32	.28	**.86**	.36	.37
	2	.32	.34	.32	.30	.24	.34	.36	.32	.33	.38	.21	.31	.19	.29	.23	.31	.34	.39	.29	.27	**.84**	.31	.34
	3	.23	.28	.31	.22	.20	.28	.29	.21	.23	.27	.15	.28	.13	.21	.15	.25	.28	.33	.26	.12	**.72**	.26	.39
	4	.42	.46	.45	.39	.35	.42	.43	.40	.42	.49	.30	.42	.29	.45	.32	.39	.46	.50	.47	.33	**.84**	.38	.48
22 Behavioral Intention	1	.52	.64	.62	.58	.46	.67	.63	.56	.59	.57	.49	.64	.44	.55	.47	.62	.68	.78	.54	.48	.41	**.94**	.33
	2	.50	.57	.61	.58	.48	.62	.60	.53	.59	.59	.44	.60	.45	.57	.44	.57	.66	.77	.56	.43	.37	**.92**	.41
	3	.58	.61	.63	.59	.53	.69	.66	.56	.63	.62	.52	.62	.49	.58	.47	.63	.73	.83	.56	.50	.35	**.92**	.27
23 Use	1	.35	.33	.27	.34	.36	.32	.36	.30	.29	.34	.15	.27	.27	.38	.31	.36	.40	.43	.34	.18	.49	.36	**1.0**

TABLE 5. DISCRIMINANT VALIDITY ON CONSTRUCT LEVEL (FORNELL-LARCKER-CRITERION)

Construct	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
1 Format	**.92**	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2 Completeness	.75	**.85**	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3 Currency	.75	.82	**.87**	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
4 Accuracy	.73	.76	.76	**.88**	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
5 Parsimony	.62	.60	.62	.65	**.82**	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
6 Information Quality	.80	.82	.82	.83	.65	**.90**	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
7 Information Satisfaction	.83	.83	.80	.80	.63	.89	**.94**	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
8 Flexibility	.78	.79	.74	.70	.57	.75	.76	**.86**	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
9 Reliability	.72	.72	.73	.76	.62	.77	.76	.72	**.89**	-	-	-	-	-	-	-	-	-	-	-	-	-	-
10 Timeliness	.78	.77	.79	.76	.63	.80	.81	.70	.83	**.89**	-	-	-	-	-	-	-	-	-	-	-	-	-
11 Integration	.61	.65	.62	.64	.47	.73	.65	.65	.63	.59	**.87**	-	-	-	-	-	-	-	-	-	-	-	-
12 Accessibility	.76	.79	.77	.75	.55	.83	.81	.73	.75	.80	.66	**.87**	-	-	-	-	-	-	-	-	-	-	-
13 Compactness	.55	.50	.56	.57	.40	.58	.55	.55	.58	.63	.47	.59	**.90**	-	-	-	-	-	-	-	-	-	-
14 Simplicity	.74	.65	.65	.63	.57	.64	.66	.64	.72	.79	.53	.71	.57	**.90**	-	-	-	-	-	-	-	-	-
15 Mobility	.59	.60	.57	.59	.35	.63	.61	.57	.63	.63	.54	.61	.69	.60	**.84**	-	-	-	-	-	-	-	-
16 System Quality	.82	.79	.76	.74	.57	.84	.85	.75	.79	.79	.65	.76	.55	.72	.68	**.93**	-	-	-	-	-	-	-
17 System Satisfaction	.82	.79	.75	.75	.60	.84	.85	.75	.80	.81	.66	.76	.57	.73	.64	.87	**.96**	-	-	-	-	-	-
18 Performance Expectancy	.66	.74	.75	.72	.57	.78	.77	.65	.71	.74	.62	.75	.56	.66	.54	.72	.80	**.91**	-	-	-	-	-
19 Effort Expectancy	.68	.60	.58	.60	.51	.61	.63	.58	.65	.75	.45	.68	.54	.86	.54	.65	.70	.64	**.93**	-	-	-	-
20 Social Influence	.45	.47	.49	.44	.46	.53	.52	.47	.43	.45	.39	.44	.32	.37	.35	.52	.51	.52	.30	**.88**	-	-	-
21 Facilitating Conditions	.42	.46	.45	.41	.34	.45	.46	.41	.43	.49	.30	.43	.27	.41	.30	.41	.47	.51	.42	.31	**.82**	-	-
22 Behavioral Intention	.58	.65	.67	.63	.53	.71	.68	.60	.65	.64	.52	.67	.49	.61	.49	.66	.75	.86	.60	.51	.41	**.92**	-
23 Use	.35	.33	.27	.34	.36	.32	.36	.30	.29	.34	.15	.27	.27	.38	.31	.36	.40	.43	.34	.18	.49	.36	**1.00**

Note: Bold numbers on the diagonal show the square roots of the AVEs; numbers below represent construct correlations

TABLE 6. STRUCTURAL MODEL RESULTS

Construct	Variance Inflation Factor (VIF)								Effect Size (f^2)								Q^2
	6	7	16	17	18	19	22	23	6	7	16	17	18	19	22	23	
1 Format	2.99	-	-	-	-	-	-	-	0.10	-	-	-	-	-	-	-	-
2 Completeness	3.76	-	-	-	-	-	-	-	0.05	-	-	-	-	-	-	-	-
3 Currency	3.81	-	-	-	-	-	-	-	0.08	-	-	-	-	-	-	-	-
4 Accuracy	3.23	-	-	-	-	-	-	-	0.18	-	-	-	-	-	-	-	-
5 Parsimony	1.95	-	-	-	-	-	-	-	0.01	-	-	-	-	-	-	-	-
6 Information Quality	-	3.36	-	-	-	-	-	-	-	0.56	-	-	-	-	-	-	0.63
7 Information Satisfaction	-	-	-	-	1.65	-	-	-	-	-	-	-	0.61	-	-	-	0.69
8 Flexibility	-	-	2.78	-	-	-	-	-	-	-	0.08	-	-	-	-	-	-
9 Reliability	-	-	3.87	-	-	-	-	-	-	-	0.05	-	-	-	-	-	-
10 Timeliness	-	-	5.13	-	-	-	-	-	-	-	0.05	-	-	-	-	-	-
11 Integration	-	-	2.10	-	-	-	-	-	-	-	0.01	-	-	-	-	-	-
12 Accessibility	-	-	3.73	-	-	-	-	-	-	-	0.01	-	-	-	-	-	-
13 Compactness	-	-	2.20	-	-	-	-	-	-	-	0.03	-	-	-	-	-	-
14 Simplicity	-	-	3.08	-	-	-	-	-	-	-	0.01	-	-	-	-	-	-
15 Mobility	-	-	2.37	-	-	-	-	-	-	-	0.11	-	-	-	-	-	-
16 System Quality	-	-	-	1.01	-	-	-	-	-	-	-	2.98	-	-	-	-	0.62
17 System Satisfaction	-	3.37	-	-	-	1.01	-	-	-	0.25	-	-	-	0.96	-	-	0.65
18 Performance Expectancy	-	-	-	-	-	-	2.32	-	-	-	-	-	-	-	1.05	-	0.49
19 Effort Expectancy	-	-	-	-	1.65	-	1.73	-	-	-	-	-	0.11	-	0.02	-	0.39
20 Social Influence	-	-	-	-	-	-	1.39	-	-	-	-	-	-	-	0.03	-	-
21 Facilitating Conditions	-	-	-	-	-	-	1.43	1.23	-	-	-	-	-	-	0.01	0.20	-
22 Behavioral Intention	-	-	-	-	-	-	-	1.22	-	-	-	-	-	-	-	0.04	0.60
23 Use	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.24

TABLE 7. PATH COEFFICIENTS OF CONTROL VARIABLES

Path	Coefficient	p-Value	Path	Coefficient	p-Value
Command Level => Information Quality	-0.010	0.771	Experience (Years in a FD) => Information Quality	-0.004	0.879
Command Level => Information Satisfaction	0.001	0.983	Experience (Years in a FD) => Information Satisfaction	-0.026	0.411
Command Level => System Quality	-0.027	0.479	Experience (Years in a FD) => System Quality	0.051	0.145
Command Level => System Satisfaction	-0.015	0.671	Experience (Years in a FD) => System Satisfaction	0.004	0.895
Command Level => Performance Expectancy	-0.002	0.996	Experience (Years in a FD) => Performance Expectancy	0.031	0.541
Command Level => Effort Expectancy	-0.037	0.500	Experience (Years in a FD) => Effort Expectancy	0.013	0.810
Command Level => Behavioral Intention	-0.038	0.314	Experience (Years in a FD) => Behavioral Intention	0.001	0.962
Command Level => Use	-0.075	0.348	Experience (Years in a FD) => Use	-0.061	0.371

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