An Initial Usability Evaluation of the Secure Situation Awareness System

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ABSTRACT

The importance of situation awareness systems in crisis-management scenarios cannot be emphasised enough. These systems enable entire disaster situations to be mapped out in a real-time fashion thereby aiding significantly in human decision-making and the necessary positioning, management and deployment of resources. As a result of the core role these systems play in responding to crises, it is vital that they are highly usable and optimized for human cognition and experience. In this paper we consider this reality in the context of an initial evaluation of the visualisation interface of a situation-awareness tool called Secure Situation Awareness (SSA). Our evaluation seeks to gather useful feedback from potential end-users on the usability of the tool's interface to feed into the design and development of interfaces for similar systems.

Keywords

Situation awareness, crisis management, usability, human experience, user testing, system evaluation

INTRODUCTION

Crisis management refers to the range of activities that respond to an immediate disaster, and preparatory actions that lessen the impact of future crisis situations (Mehrotra et al., 2008). Situation awareness (SA) by nature therefore constitutes a central part of crisis management as it provides an in-depth understanding of the state of an environment inclusive of the relevant informational parameters and situational knowledge (Endsley, 1995). There is no shortage of crisis-management scenarios today, both nationally and internationally, where high levels of SA are vital for individuals, NGOs and, particularly, government responders and agencies. Some of the most striking events in 2011 include the tsunami and consequent Fukushima nuclear plant disaster in Japan, the summer riots in the UK, and the bombing and shooting spree in Norway. All of these crises required responders quickly to become aware of the situations at hand and gather pertinent information (status, location, etc.) on critical assets, potential threats and response options. These are some of the main goals of SA systems, which affirm their use and importance.

Apart from satisfying functional requirements, SA systems must be highly usable and wherever possible, optimised for human cognition and decision-making. The need for usability in software interfaces is well documented (Nielsen, 1993), including for critical systems (Redish, 2007). For example, consider a scenario where a Gold commander in an emergency operations centre (EOC) has various streams of incoming information from numerous sources regarding an on-going crisis. SA system interfaces therefore need to be designed in such a way as to facilitate understanding of the scenario and enable the commander quickly to assimilate that information in order to make decisions on response actions that may ultimately save lives. Clunky, inefficient or difficult to understand interfaces are not a luxury that can be afforded at these times.

Following on from the discussion above, in this paper we have one main contribution and aim – to report on the initial evaluation of the visualisation interface of the Secure Situation Awareness system. To achieve this aim, we begin by first recapping SSA and providing a brief overview of the tool. This tool is a feasibility demonstrator developed by Thales UK Research and Technology specifically to investigate how to address the

increasing demands placed on SA systems today, and also to investigate multilevel security for SA in terms of the secure collection and selective sharing of crisis-management data. Next, we report on the initial design evaluation of the SSA's visualisation interface. The intention here was to gather feedback from potential users on the usability of the tool's interface, assess this in light of usability principles, and then to feed findings into the design and development of interfaces for similar systems.

THE SECURE SITUATION AWARENESS (SSA) SYSTEM

The Secure Situation Awareness (SSA) system aims to provide another useful tool in the arsenal of crisis managers and incident responders. In addition to possessing many of the features prevalent in typical SA systems (e.g., the ability to present temporal and geographical information and assets, track resources, search/filter information, and so on.), SSA focuses on an incorporation of the underlying security requirements which are imperative for adequate and efficient crisis response. Security is an important factor because of the fact that during crisis-management situations, although information will be shared between various groups, there may be a need for a level of protection for certain items of information contained within shared areas, in order to keep them within defined communities (or roles) of interest for example.

The SSA provides an interface for data entry and visualisation, with data entered using one instance of the system available to other users according to their needs and pre-defined security clearance. The users do not need to be collocated, as the system is accessible via the Internet and information is shared online using encryption. The visualisation allows data from multiple sources to be displayed using Web mash-up displays. Such displays allow content from different sources to be shown on a single integrated view, thus enabling end-users to understand how separate items of information relate to and influence each other. Most existing SA tools we have seen show different sources of information on different displays, thus adding to the amount of interpretation and to some extent cognitive processing required by the end-users. Figure 1 shows two screenshots of the SSA interface; see Craddock and Waller (2007) for further detail on the tool.

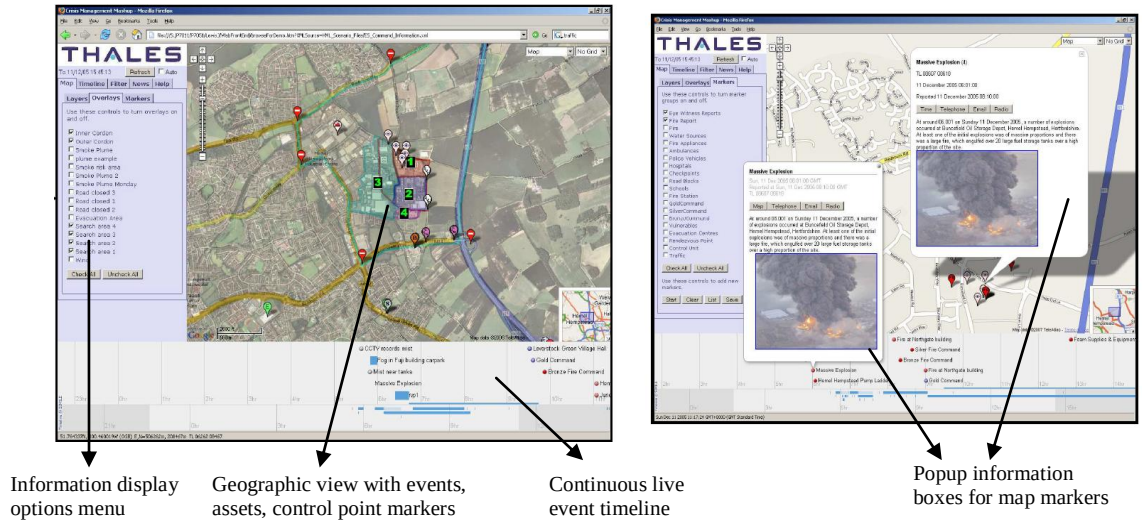

Figure 1. Left: SSA interface focused on an area and incident (consisting of multiple events); Right: SSA map markers pop-up to present additional information on an incident (including text, images, audio and video)

In the very early stages of SSA's design, there was some notable emphasis on usability which involved incorporating implicit and explicit feedback from user observations, interviews and design mock-up appraisals. SSA was also especially designed to assist with the problem of operator data overload. Users can specify who particular items of information can be shared with, and the information sharing rules allow for the inclusion of role. To reduce information overload, each command level is only shown the information relevant to its responsibilities and tasks. For example, Gold commanders are not shown the location of every individual responder at an incident as it clutters their display, and Bronze commanders do not need to see the minutia of information for incidents other than their own. Users can also choose which types of information (generic information types or specific information items) to visualise on the display using the Information display options menu (Figure 1). This allows them to tailor and enrich their SA according to their specific needs. The next section builds on this overview of SSA and reports on the usability evaluation.

EVALUATING SSA

Usability and Methods of its Evaluation

The International Organization for Standardization (ISO) defines usability as the "effectiveness, efficiency and satisfaction with which specified users can achieve specified goals in particular environments"; here, effectiveness looks at whether the user can carry out the task, efficiency considers timeliness of task completion, and satisfaction assesses user acceptability and comfort using the system (Faulkner, 2000). Nielsen (1993) supports and supplements this view with his five key attributes for system usability. These are learnability, memorability, errors, efficiency and satisfaction. Each of these constitutes crucial aspects to the usability of any system being designed and developed, particularly those that assist in crisis-management situations; both for the severity of these situations and the added degree of complexity of these systems. Redish (2007) and Paulheim et al. (2009) stress the difficulties when dealing with usability and the general human experience within complex systems, and Endsley et al. (2003b) provide a noteworthy capture of the challenges to good SA.

Literature mentions two general methods for evaluating systems: user studies and expert- (or heuristics-) based evaluations (Rosenbaum, 1989). The former is usually preferable because it employs potential users and therefore better mirrors actual user behaviour and experience of use of the proposed system. Thus, for our initial evaluation of SSA we adopted such an approach. In addition to testing the system's usability attributes, this would also unearth any unforeseen shortfalls in the tool's interface design. To complement these experiments, in the future we also intend to engage in a heuristics-based evaluation of such interfaces. This would enable us to draw on a variety of time-tested heuristics and determine how well such systems perform in light of them.

User Studies

To evaluate SSA, we used one of the largest Fire and Rescue Services in the UK, serving a county which contains a wide range of different environments and scenarios, including urban, rural, maritime, industrial and aviation. The service personnel who participated in this evaluation were individuals that regularly use crisis-management systems to make decisions and give informed advice to responders; the Gold commander and Silver commander who headed up exercise teams had over 35 years of combined experience. Since this study was an *initial* evaluation of SSA, our core goal was an exploratory investigation to gather feedback on user experiences and usability of the system in performing common crisis tasks. This feedback would then be incorporated in future system design iterations to form the basis for much more rigorous evaluations. Although exploratory, this investigation was considered worthwhile because: the concept of sharing data between agencies using an SA system was very new to the users, there were not many SA systems in use by the emergency service in question, and the users had a wide range of technical knowledge/experience/comfort.

The first activity of the study was a training session for study participants on SSA and how to use it. This session provided insight into the tool's functionality and how standard informational and command-and-control tasks could be completed. In the week following that session, study participants then took part in an exercise where they used the system for a simulated crisis scenario. The scenario consisted of a fire in a local cathedral during a busy service. Direct road access to the site was limited to a set of one-way narrow streets lined with historical buildings and the congregation of over one hundred people included the elderly and disabled. The incident required the deployment of multiple emergency services. During the exercise, two teams – mimicking Gold and Silver command were setup in separate rooms, with communication between them being via radio and SSA. Following the exercise, unstructured interviews were held in which participants provided feedback on how usable (defined loosely by the attributes from the previous section) they found SSA in assisting crisis response and any changes they believed would enhance human experience. The main feedback points, selected as they were the most outstanding and clearly defined across the user group, are discussed below.

Interface customisation – The first key finding was the importance of allowing/facilitating customisation of SSA interfaces, including the information presented within those interfaces. Although the system was originally designed to assist with the problem of operator data overload (with multilevel data and access rights), it was felt that more could be done with respect to customisation features regarding what should be displayed and *how* it should be shown. Currently the system was more geared to the 'what' through the use of multilevel data and information access. Additionally, although we assumed that senior end-users such as Gold commanders will be more interested in high-level and summary information (e.g., reports) from a tool, they still desire the option of viewing detailed logs or all incoming information. Thus these capabilities should be provided, for instance, having settings to toggle information granularity. Furthermore, customisation-related feedback also surfaced regarding interfaces being better adapted to different types of end-users, tasks and potentially even user skill-sets. Subsequent SSA designs should therefore seek to allow for appropriate levels of customisation and ease in that process. Customisation links to the usability attributes of learnability, efficiency and satisfaction.

Multiple methods of data input – At some stages where data input in SSA was necessary, participants reported that this activity was somewhat inflexible and unsupportive. One example cited was during the entry of query parameters necessary for centring on a particular location – a common task when system users were trying to locate or place resources or information assets onto the map interface. In addition to being able to input actual address parameters (as SSA allows), participants desired the ability to input other formats including single post codes and geocodes with longitude and latitude; this may have been linked to personal preference or because data from sources were in these extraneous formats. For them, simple capabilities such as this could raise efficiency, lessen strain on users to do the format conversion and decrease likelihood of errors being made. The general point therefore was towards increased interface (input) flexibility and support. For the future we should look to build on this feedback and apply it to other pertinent areas of SSA where allowing multi-mode inputs might be useful both to support users by easing cognitive demands and speeding up system interaction.

Use of view displays – Another issue raised was in the ease of use (especially manipulation and understanding) of information view displays, inclusive of maps. To take the information boxes which pop-up upon clicking a marker as an example (see Figure 1: Right), participants generally found this valuable but complained about the inability to manipulate the box size. Converse to our initial design aims of not occluding underlying content or risking information overload, they felt that the boxes should have been larger to enable them to see as much information as possible regarding that marker (recall, markers can represent anything from eye-witness responder reports to locations of resource assets). Another benefit cited for enlarged displays or indeed the opening of new pop-up windows to be displayed on adjacent screens, was that it presented users with all the pertinent information and removed the need for continuous scrolling. From a cognitive perspective, excessive scrolling is likely to be undesired as it would require users to remember content and detail that may be out of sight when a crisis event was being assessed. In the typical high-stress, time-critical crisis situation, this reality would be far from ideal and may also negatively influence the decisions' effectiveness. Future designs should consider how a balance between this aspect and others such as information overloading could be reached.

Effective and efficient information communication – Further to the point above, the emergency service personnel also highlighted a few potential inefficiencies on how information itself was communicated to users by SSA. One of these aspects was that colour should be utilised in more cases (guided by context/appropriateness) to enable quick and effective information consumption by personnel. These usage cases should generally encompass on-screen information, incident data and even detailed logs; these are informational situations where consistent colour-coding could allude to severity, timeliness or importance, and thereby act as an instant visual indicator for system users. Colour had been applied in SSA previously for similar purposes (drawing on general guidelines such as those mentioned in Galitz (2007)) as can be seen from the figures above, but not to the extent and scope now suggested by participants. The next iteration of design should therefore reflect on the usage, importance and peculiarities of colour, contrast and salience within the SSA crisis-management displays. In addition to colour, there is also need for further work on the interface design in terms of information and risk communication to system users. Risk perception and communication are relatively mature fields which have been researched in detail for many years, particularly within the medical and natural-disaster domains. As such, there are numerous guidelines proposed (see Lipkus, 2007; Marewski et al., 2010) regarding presentation formats (visual, verbal and numeric), cognitive barriers to understanding that humans face and heuristics and biases, which will be useful in assisting the effective and efficient communication of information and risk data.

CONCLUSION AND OUTLOOK

To support EOCs and other crisis responders, reliable, effective and secure SA and crisis-management systems are imperative. By their very nature and as a result of how closely humans interact with these tools, however, a significant amount of effort must also be invested in achieving good system usability, optimising interfaces for cognitive processing and supporting the wider human experience. In this paper, we have made initial steps towards satisfying these needs through the proposal and preliminary usability/experience evaluation of the SSA feasibility demonstrator for SA. Apart from supplying useful feedback for further research, our findings also cement those of related works and therefore underline areas of particular concern in the SA design domain. These works include Endsley et al. (2003a) in terms of levels of information and customisation to suit user roles, Paulheim et al. (2009) which focus on minimising learning effort and errors in system usage, and Prasanna et al. (2011) in relation to proper use of salience, usefulness of data input interfaces and appreciating users' limited working memory. To briefly reflect on our evaluation methodology, we do believe that user studies were valuable in providing guidance for future designs. To develop a more user-centred system, greater emphasis could have been placed on human-centred rather than technology-centred design approaches during the initial design phases. This would include a comprehensive examination of user workflows and detailed ethnographic studies, the outputs of which would inform the design of the visualisation interface of the SSA. Subsequent evaluations would then provide more information related to the resulting user-centred system.

Our intentions for future work are centred around the advancement of the design and interfaces for crisis management SA tools, drawing heavily on evaluation findings (from user studies and planned heuristics-based analyses) and other relevant guidelines in crisis management and general usability/human experience. Following this, we envisage that the next iteration of evaluation will be significantly more comprehensive and feature real-time system use, expert evaluation and more structured data-gathering and assessment techniques such as screen recording, user observations (if feasible) and structured interviews, as described in Redish (2007) for the appraisal of complex systems. This evaluation will also be extended to encompass other key areas of interest within these types of systems, including human factors and experiences within collaborative/coordinated work. For future experiments, one avenue in particular – which we have already started to scope – is the usability of the security features within SSA; this was covered only briefly in the initial evaluation. Multi-level security is an aspect of crisis-management SA which is typically overlooked, but is critical, especially when multiple agencies or countries are involved in managing a crisis. This future work would encompass assessing how typical SA system users react both in terms of setting up general security rules to cover generic types of information and types of recipient, and in terms of tailoring the rules for specific items of information and/or specific recipients. To add complexity to the issue, the variable levels of security concept is a reality that we note may be new to crisis management users, and as such they would not only have the interfaces to understand but also multilevel security. There are various works in the usable security field (e.g., Nurse et al., 2011) which will prove useful to guide these evaluations.

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