REPRESENTING AND VISUALIZING A DYNAMICALLY CHANGING TACTICAL SITUATION

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In a research project investigating information requirements for increasing SA in the attack helicopter domain, we examined issues concerned with the presentation of dynamically changing information about a tactical situation. We explored features including an underlying digital map, supplementary unit information, and dynamically updated information about enemy and friendly unit movements. We found that although continuous updating would most accurately represent the current tactical situation, periodic updates were more successful in making subjects aware of the changing enemy and friendly dispositions, thereby supporting higher levels of SA. We found that some features rated as highly useful were not actually invoked during the simulation, suggesting that subjective evaluations of utility of display features may be a misleading indicator of their actual usage.

INTRODUCTION

In the military domain, tactical information such as enemy and friendly dispositions is rated as extremely important for maintaining high levels of situation awareness (SA). A widely used definition of SA is one proposed by Endsley (1995) who defines SA as being comprised of *perception* of events in the current situation, *comprehension* of their meaning, and *projection* to future situations. In a research project exploring approaches to increasing SA in the attack helicopter domain, we investigated various types of information and methods for presenting dynamically changing information about the tactical situation to support the perception, comprehension, and projection aspects of SA.

Prior to the development of the displays, experienced attack helicopter pilots rated the relative importance of a set of situational elements for each of four phases of an attack helicopter mission (planning, ingress, battle position, and egress). Information about the current situation of enemy and friendly units, and enemy ADA support were very highly rated across the phases of the mission for tactical SA.

We also conducted a preliminary study in which we assessed the value of including digital map under a geographically based display and continuous dynamic updating of information about enemy and friendly units (Entin and Zeller, 1997). Most of the subjects who did not have the digital map stated spontaneously that they felt there should be a map. Subjects with the digital map and automated updating spent less time and effort, and were more effective in plotting a route to a new location that took advantage of the terrain and geographic features of the situation (for example, to go around population centers) and did not expose them to enemy fire. Based on the results of this preliminary study we concluded that both the digital map and automated updating were effective for enhancing tactical SA.

We asked subjects who participated in the preliminary study what features they would suggest for supporting tactical situation awareness. Among their suggestions were the ability to declutter the display, supplementary information about enemy and friendly units (for example strength, call signs, type of weapons, and speed of movement) and a history (or trace) of enemy and friendly unit movements from planning to the current time.

Applying both the rating information and study findings, we developed a user-system interface and conducted an experiment in which we investigated issues concerned with the display of dynamically changing information about a tactical situation. We analyzed the value of the information, subjects' use of that information, and the relationship between subjects' evaluation of the information and their usage of it.

METHOD

Experiment Materials

To conduct this research we developed the Situation Awareness Testbed (SAT), a simulation that captures key aspects of the multifunction displays (MFDs) comprising the CSI for the AH-64D Longbow. We focused on the Tactical Situation Display (TSD), which portrays a dynamic, geographically based representation of the tactical situation, including enemy and friendly locations, boundary points, and control measures, and implemented a number of the display features requested by subjects in the preliminary study. We concentrated on features that were not available in the Crew System Interface (CSI) for the AH-64D Longbow, the Army's most advanced attack helicopter, at the time of this research.

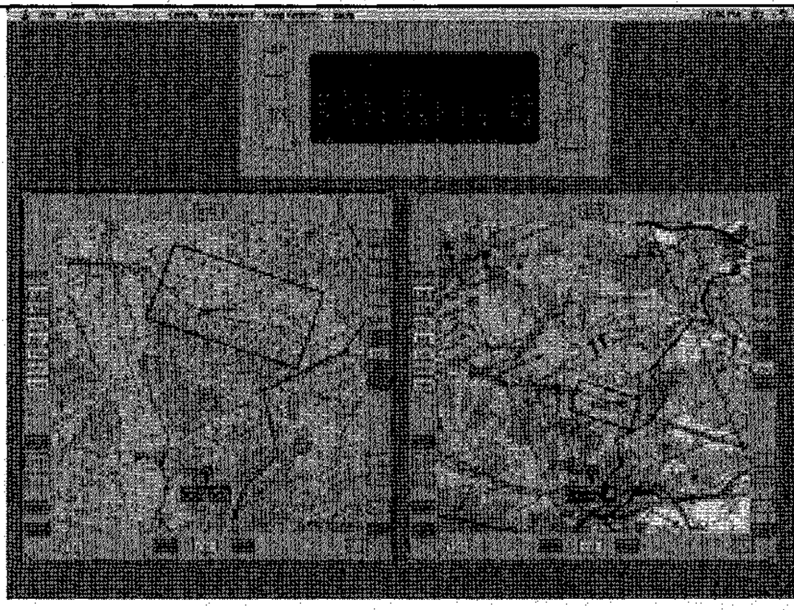

Figure 1. Example of SAT Interface with Up Front Display and Two TSD Views. An ADA Fan Covers the Left Hand TSD and Partially Covers the Right Hand TSD.

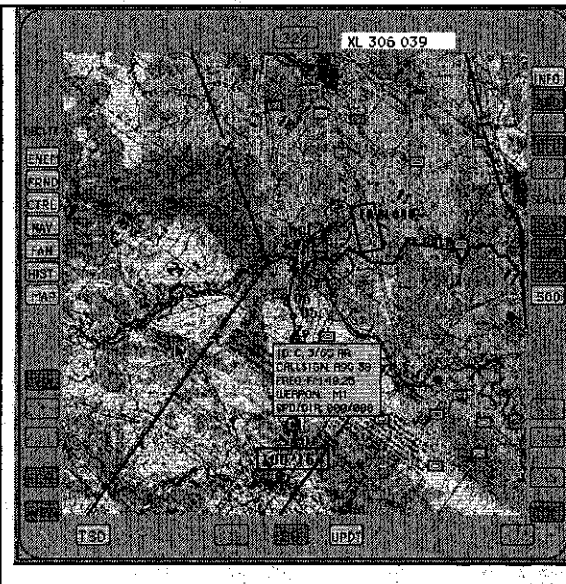

Figure 2. Example of TSD with Supplementary Unit Information Displayed.

An example of the SAT encapsulation of the CSI is shown in Fig. 1. At the top of the figure is a representation of the Up-Front Display (UFD), which conveys call signs and notifies the crew when updated information is received. The Longbow CSI has two MFD panels. In Fig. 1he left hand panel shows a more detailed (1:100 scale) view of the TSD and the right hand panel a wider (1:250 scale) view. The figure also shows the ADA fans on both TSDs. The buttons along the top left hand side of each panel allow the operator to control the features that are displayed on the TSD. Buttons on the right side allow the operator to change the map scale. Figure 2 shows an example of supplementary unit information that was available on the TSD.

Members of a National Guard AH-64 attack helicopter unit participated in this research. The scenarios for the experiments involved a night attack helicopter mission supporting friendly armor and mechanized forces against armor and mechanized opposing forces in a mountainous terrain.

Experiment Design

In the experiment all subjects has use of the digital map and received updated information about unit movements. Updating was provided periodically rather than continuously. Notification that enemy and friendly positions were updated appeared on the UFD. Features suggested by subjects in the preliminary experiment that were incorporated into the SAT included: an increased number of map scales, declutter buttons; provision of supplementary unit information, and unit history information. We captured the user's interactions with the testbed, thereby allowing us to evaluate usage of the display features that we provided, as well as their perceived utility.

The only feature systematically varied in this experiment was unit history information. Half the subjects saw only current locations of enemy and friendly units. The other half could see a graphical trace of each unit's path of movement since the start of the scenario. We hypothesized that a picture of how enemy and friendly units have evolved to their present locations would support the comprehension and projection aspects of SA.

RESULTS

We analyzed the subjects' interactions with the SAT to ascertain what features of the displays they used and examined the effectiveness of these features for maintaining SA. We also compared subjects' usage to their ratings of utility of the display features.

Map Scales

Selection of a large map scale (e.g., 1:500) affords a view of a wide area but makes it hard to see individual features. A small map scale (e.g., 1:50) makes more details visible but limits the view. Subjects reacted positively to the availability of a variety of map scales and used them all over the course of the mission. The most frequently used configuration was to have one TSD on the 1:100 scale and the other one on the 1:250 scale. These two scales are the ones that subjects rated as most useful. Subjects found the 1:100 scale map to be an effective compromise between a large scale map that shows the big picture and a small scale map that shows details of a particular area, and used it through all phases of the mission. This was particularly interesting in that subjects who participated in this experiment were not used to flying with a 1:100 scale map.

Declutterable Features

The most notable discrepancy between subjects' ratings and their behavior was in the use of the declutter buttons. Many subjects commented that they liked having (and subjects in the preliminary study had requested) the ability to control the display of features that were overlaid on the TSD (e.g., unit, control, and routing information). Except for turning off the ADA fans, however, very little of the layered TSD information was deleted from the displays. Although subjects wanted the capability of removing information from displays because they believed it would make critical information clearer, in the simulations, they did not seem to invoke that capability, either because the information did not actually clutter up the display or because they found they wanted to see the optional information that is provided. The one feature that was sometimes removed from the display, the red-colored ADA fans, was rated as the most useful of all the declutterable features. Subjects tended to delete the fans when they encompassed the entire area shown on the TSD. In other words, subjects decluttered a valued but perceptually dominant feature when it no longer provided discriminating information.

Unit Updating and Supporting Information.

Periodic updating of unit positions and supporting information about enemy units were two of the three most positively rated display features.(6.6 and 6.7, respectively on a 7-point scale). We observed in the experiment that the notification of unit updates on the UFD was helpful for making subjects aware that units had moved. The usage data indicates that subjects took advantage of supplementary unit information feature of the display. The most extensive usage of this feature occurred during the planning segment when the simulation was stationary and subjects could interact with the displays as long as they wanted. The mean number of requests dropped from 24 in this segment to 13.5 in the ingress segment and 0.7 in the battle position segment when subjects began focusing on identifying and prosecuting targets.

Unit Traces

Subjects who had the graphic portrayal of the unit trace information available were positive about that feature of the display (mean = 6.2). All but one of the subjects who had the unit history trace function available left it on all the time. Thus, there was no evidence that this feature made the displays more cluttered than was tolerable. A number of subjects commented that it was difficult to follow the unit history information because as the simulation progressed unit movements became more complex and the traces began to cross over one another. The trace information was somewhat easier to follow when the digital map was off, but most subjects kept the digital map displayed on the TSD throughout the simulation. Apparently they felt the information gained from the map was more useful than having a clearer view of the unit history information.

There were no significant differences between the subjects who had the unit history information available and those who did not on aspects of SA concerned with disposition of enemy and friendly units or on overall SA. Yet this feature was one suggested by subjects in the first experiment as something that would support SA. The lack of evidence for utility of unit history information may be attributable to the way we implemented this feature. Or it may mean what it directly suggests: that historical information is not a critical elements of SA, and the only thing that matters is where the units are at the present time.

DISCUSSION

Conclusions

Evidence for the utility of dynamically updated information came from subjects' performance on tasks such as plotting a safe and efficient route to a new location, or finding the closest location where they could rearm and/or refuel. We concluded the periodic updating of unit information is more effective for maintaining SA than is continuous updating, even though the latter provided a more accurate minute-to-minute reflection of the situation. In this experiment we provided a message on the UFD and included a low level auditory sound when updated information was received, and found that was a satisfactory methodology. Subjects did not find the notification intrusive or distracting, and did find that it brought the fact that the tactical situation had changed to their attention. This is particularly important for helicopter missions that occur over relatively short time periods. Because ground units can only move a limited distance, the changes might not be noticed by a helicopter crew unless it is brought to their attention. Indeed we had noticed that problem in the preliminary study in which we implemented dynamic updating as continuous rather than periodic movement. In that study many subjects were not aware that units had moved, even in the case of an enemy unit that had crossed the boundary between enemy and friendly territory.

We could not demonstrate that the unit history information significantly improved subjects' tactical SA, perhaps because of the way in which it was implemented. As noted previously, the unit traces were sometimes difficult to follow. As the units moved about, the trails become longer and in some cases fell back on themselves. When there are a number of units on the map, the trails becomes intermixed and it is difficult to disentangle them. The unit history was implemented on an all-or-none basis. We concluded it would be useful to provide the capability to highlight the trail for a particular unit, so that the trail for the unit of interest can be differentiated from the others. It is also possible that showing only the current direction of movement for each unit may be sufficient to maintain a high level of tactical SA.

We concluded that subjects' a priori notions about what information and capabilities they require is not always a valid indicator of the utility or usage of that information or capability. For example, we noted that subjects requested a declutter feature but did not make much use of that feature. This outcome demonstrates the importance of empirical evaluation in which users interact with a proposed interface in simulated missions, even in projects in which users are involved in the requirements and preliminary evaluation phases of development, as was the case in this work.

In the preliminary study, subjects rated their own SA about various aspects of the tactical situation. The self-ratings were uniformly high, and there was a large discrepancy between them and a measure of SA derived from the subjects' responses to questions about the tactical situation. Based on this data we concluded that subjects' own evaluation of their SA is not a sensitive measure of the effectiveness of display features for enhancing SA. This finding supports results reported by Bell and Waag (1995) who also found that airmen's self-ratings of SA were not consistent with those provided by supervisors and peers.

Supplementary Issues

Neither the notification that updates have occurred nor the unit traces themselves makes the units that have moved in the last update perceptually salient. One approach would be an optional display button that would highlight the icons of units that had just moved, for example by showing them in reverse video. An alternative would be to highlight the icons automatically.

When updates occur, the changes may not be visible to the operator if they occur outside the geographic area currently shown on the TSD. Alternative methods of notifying the crew member of which scale must be selected to see the updated units can also be explored. One possible mechanism would be to provide a button which, if selected, would automatically change one of the TSDs to the map scale needed to view the updates.

The TSD is oriented in the direction of flight. About a third of the subjects said that regardless of the direction in which they are going, they fly with their maps oriented so that North is up. They suggested an option which would allow the operator to select the orientation of the TSD. But because the location of ownship is fixed closer to the bottom of the TSD, by orienting the map in the direction of flight, the crew gets the maximum view ahead of them. In a south-oriented scenario, for example, if the map were turned around, most of what is displayed would be behind, rather than in front of ownship. Subjects acknowledged this limitation, but some still wanted the flexibility to orient the display as they preferred.

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