Digitally Enhanced Situation Awareness: As an Aid to Battlefield Decision-Making

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Abstract

In combat and tactical situations, situation awareness is a key factor in the quality of decision-making. Currently, the US Army is investigating using digital systems, such as computer networks, digital imagery, and GPS, to enhance situation awareness at all levels of command. This article illustrates how digital technology is currently being used to enhance decision-making at the unit level and provides suggestions for how further advancements can be made. Further discussion is giving on the advantages of digital and embedded training in these areas.

Introduction

The military follows a chain of command in combat and decision-making. The higher echelons make broad decisions and each echelon below further refines the orders to address their part of the overall objective. In combat, situation awareness (SA) is a key factor in the quality of the decisions which are used to direct military forces. Any method that increases the commander's situation awareness also increases the effectiveness of the military unit.

Billings (1997) argues that the purpose of automation in aviation is to increase the aircrew's situation awareness. This is the same function that digitization, a form of automation, provides for the military decision-makers. Digital systems not only enhance situation awareness, but also facilitate shared situational awareness, which translates to a clear, accurate, and common picture of the battlespace for leaders at all levels.

In the past, scouts, observers on high ground, and even balloons have been employed to acquire information needed by commanders. Once acquired, this information must be transmitted to commanders by the best means currently available. In the early twentieth-century, information was communicated by signalmen and Morse code. World War II brought the radio to speed information back to the decision-makers.

Current technology has brought advanced sensors and satellite communications to the battlefield, bringing situation awareness to the decision makers faster and with more detail than ever before. Now, the key to decision-making is not only getting the information, but also filtering and using the information effectively.

Situation awareness is key to making decisions on the modern battlefield. To understand how digital systems support the commander's SA, it is first important to review situation awareness, battlefield decision making, and how the US Army uses digital systems.

Furthermore training of these types of technologies, by their nature as embedded equipment, support embedded training. An embedded trainer can be defined as a capability resident within the operational equipment that allows the trainees to use the operational equipment to receive training and practice skills (Andrews1991). Therefore skill acquisition will be quick and adequate for functional use.

Background

Throughout history, commanders have understood the importance of battlefield situation awareness in decision-making. Military operations are frequently shrouded by uncertainty (Von Clauswitz, 1984). This uncertainty has

often been described as the "fog of war." The objective of obtaining tactical information was, and still is, to reduce this uncertainty. In a sense, situation awareness can be seen as the opposite of, or the counter to, the fog of war.

Situation Awareness

Situation awareness has been examined by a number of researchers, including Endsley, Fracker, and Harman and Secrist (Garland, Phillips, Tilden, and Wise, 1991). Randel, Pugh, and Reed (1996) studied situation awareness in the context of naturalistic decision-making. They found the ability to make better decisions was based, in part, on better situation awareness. In a similar study, Kaempf, Klein, Thordsen, and Wolf (1996) investigated how SA influences decision-making in a Navy Combat Information Center (CIC) and found that SA is an important factor in decision quality.

Endsley has developed a model of situation awareness. She suggests information about the environment is brought by the senses into the working memory, where it is formulated into a mental model of the outside world. Her model of situation awareness includes three levels: 1) a perception of the elements of the current situation, 2) comprehension of the situation, and 3) projection of future status (Endsley, 1995).

The US Army sees situation awareness in a much simpler form. SA is seen as the commander's mental model of the battlefield. Most often the term is used to describe information available on Tactical Operations Center (TOC) displays which allow commanders to develop this mental model. Such displays are often referred to as "situation awareness displays." The purpose of such displays is to provide decision-makers with enough information to make quality decisions.

Battlefield Decision-Making

The US Army has a formal process for planning military operations called the Military Decision-Making Process (MDMP) (Department of the Army, 1997). This process is not decision-making in the cognitive sense, rather it is more akin to structured problem solving.

Once plans are executed, decision-making becomes more cognitive and often follows the Recognition Primed Decision-Making model described by Klein (Adelman, Leedom, Murphy & Killam, 1998) where knowledge from the decision-maker's past experience is used as a framework for decisions about the current situation. Decision-making while units are in combat is characterized by the requirement to make decisions quickly. Often, commanders are bombarded with large amounts of information in various forms and must attempt to form a mental model of the situation to use as a basis for decisions. The limits of working memory preclude decision-makers from considering much of the information available (Wickens, 1992).

Digitization

The US Army digitization program seeks to capitalize on networked computer systems to enhance information flow and display. Theoretically, this allows decision-makers to maintain a clear and accurate vision of the battlefield necessary to support both planning and execution (Program Executive Office for Command, Control, and Communications, 2001).

In an Army unit equipped with digital systems, information is typically stored in common databases and can be accessed through a tactical internet, much like the global Internet. Much of the information, such as unit positions, can be displayed spatially as graphics, which is much easier to process cognitively.

The hardware of digitization presently consists of a family of systems. Each staff element, Intelligence, Artillery, Logistics, Air Defense, and Maneuver, has a computer system specifically designed to meet its unique needs. However, this entire family of systems is networked together to share information. The final member of this family is a computer system which is customized for lower echelon units, the troops in the field. This system, known as the Force XXI Battle Command, Brigade and Below (FBCB2), allows access to the information network down to individual fighting vehicles, such as tanks and infantry fighting vehicles.

Digital Systems To Enhance SA: Current Methods

This digital network allows commanders to maintain an awareness of their subordinate units, known as friendly SA. In mechanized units consisting of tanks and infantry fighting vehicles, for example, each vehicle tracks its geographical position by means of a Global Positioning System (GPS) receiver. Periodically, its position is transmitted back to the unit network where it can be displayed on the commander's computer. This ensures the commander knows the location all the unit's vehicles at all times. A study conducted by McGuinness and Foy (2000) found commanders rated this factor to be one of the most helpful.

As well as friendly SA, commanders also require SA concerning the enemy. Military Intelligence specialists access advanced sensors to locate enemy units and enter information into the database. Once the location of enemy units on the battlefield can be accurately presented, commanders can recognize patterns of activity and estimate the enemy's intent. With this information, the commander's options will become more clear.

Similarly, each individual vehicle equipped with FBCB2 can access the same information; therefore, soldiers in the field are aware of the location of other vehicles in the unit in relation to enemy units. Because the digital computer systems are in the hands of leaders and soldiers alike, digitization provides not only improved situational awareness but shared SA. This timely sharing of information allows better coordination among units and significantly improves the ability of commanders and leaders to make decisions quickly. (Department of Defense, 2000).

Future Possibilities

Through the application of advanced technology on the battlefield, the Army is well on its way to establishing full situational awareness (Department of Defense, 2000). The problem with displays to enhance situation awareness is not just presenting the information, but presenting it in such a way that it can be processed by the decision-maker into an accurate mental model of the situation. Simply presenting more information does not ensure better SA. In fact, presenting too much information can overload the recipient and actually inhibit SA. Displays that take advantage of an understanding of human information processing could present more useful information to the decision-maker.

Commander's HUD

Considerable effort has been expended producing Head Up Displays (HUD) in fighter aircraft to enhance the pilot's SA. The essence of the HUD is to present real-time information in the center, or focal, part of the display and include status or secondary information around the periphery. This allows pilots to focus attention on the most important information in the center of the display, yet perceive secondary information while minimizing the attentional and perceptual cost of accessing the information.

The same technology might be used to provide see-through displays for lower echelon commanders, such as tank or infantry fighting vehicle commanders. Computer generated graphics might be projected onto vision blocks and external sights to present important mission-oriented information such as navigational way points, suspected targets, or danger areas.

For example, as a vehicle approaches an area known to be mined, an image could be projected into the vision blocks so that the area appears to glow red, an indication the area is dangerous and should be avoided. Or, since the positions of friendly forces are known, symbols for friendly vehicles could be displayed in the tank gunner's sight to help the gunner distinguish between friendly vehicles and enemy targets.

Minimizing Information Access Cost

One of the difficulties in designing head up displays is that the information presented in the periphery should be in a format which is easy to perceive and process. Typically, such information is presented in symbolic or spatial formats. For example, a display in a helicopter may present the aircraft's altitude above the ground as a bar on the side of the display that rises and falls as altitude increases and decreases. This symbology is easier to process cognitively than forcing pilots to convert numbers to height above ground.

Similar modeling could be used for digital displays to allow commanders to more easily process information. Minimizing information access cost, that is, reducing the amount of cognitive effort required to perceive information, is an important consideration in display design (Wickens, Gordon, & Liu, 1999). Suppose a commander had a geographical display that showed his forces in spatial relationship to enemy forces and significant terrain features. Peripheral information could also be displayed on the edges of the display, provided they had the appropriate perceptual coding.

For example, the status of each of the commander's subordinate units could be displayed as color-coded symbols. Each unit might have a symbol for fuel status, ammunition status, and personnel status, coded green if the status was acceptable, yellow for marginal, and red for unacceptable. The status of subordinate units would be readily apparent. Any symbol that was not green would focus the commander's attention on that unit. The commander could then access more specific information on the unit's status by selecting it with a cursor. Such a status display would enhance the commander's SA of unit status. Using color-coded symbols would reduce cognitive information processing costs.

Currency of Information

Other techniques could be used to project information at low cognitive loading. For example, one important consideration of situational displays is how current the information is. Icons that symbolize a moving unit may not be updated on a regular basis. Therefore, the unit may not be where it is depicted by the symbol. If it is not possible to update the symbol in real time, the viewer should be able to tell how long it has been since the last update.

A technique used in some computer games is to have the symbol "fade" out as information ages. This fade-out is accomplished by changing the colors from bright to dim over time. Such fading takes advantage of user experiences in the world, a technique known as mapping (Norman, 1988). Many physical objects fade in color as they age. The fading of the symbols maps the fading of objects as they get older. This type of natural mapping

uses minimal attentional resources to process the information.

Predictive Aiding

Wickens, Gordon, & Liu (1999) suggest that since predicting future events is a difficult cognitive task, it is an ideal task to delegate to automated displays. Prediction often requires complex mathematical calculations, which, although difficult for people, present little problem to computer systems. Predictive aiding could support situation awareness by helping the commander to visualize the relative positions of friendly and enemy forces at a future time.

Predicting where moving units will be in the future, how much fuel they will use, and when critical events should occur are all well within the abilities of digital systems.

Training

With the progress in the development of techniques, such as user modelling and capture of real-time operator data, the potential for an automated comparison of operator performance against training objectives in real time, and the provision of on-line feedback, or remedial instruction to the trainee is available for these skills (Zachary, Ryder, Hicinbothom & Bracken, 1997).

Conclusions

Generally speaking, the better information a decision-maker has, the better decisions are made. The use of digital automated systems to increase situation awareness is a promising method to allow decision-makers to develop a more accurate mental model of the situation, and consequently increase the quality of decisions.

This high level of information gathering and sharing is not limited to military applications. In the civilian world, digital enhancements for SA can be used to help guide drivers through congestion areas, monitor crowd movement at major events, such as sports or political gatherings, and better match public transportation to the changing needs of its patrons.

The ideas listed in this paper are merely examples of how electronic information processing and display tools can help enhance situation awareness and support decision-making. The intelligent application of human factors to systems design should provide a wide range of technological aids to support human information processing and decision-making.

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