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The Impact of Information Displays on Decision Making

by John Shevlin, Marc Jackson, Sue E Kase, and Daniel Cassenti

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14. ABSTRACT
Information superiority equals combat superiority on the battlefield, according to Network Centric Warfare. Today's battlefield requires Soldiers to be able to gather and process large amounts of data to successfully complete their mission. Shadow Force is a test to see if information displays can change mission effectiveness. This iteration of Shadow Force focuses on testing 2 different display methods, map-based display and text-based display, to see which is more effective and would allow Soldiers to complete the mission with a greater degree of success.

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Contents

List of Figures

1. Introduction

The flow of accurate information and proper situational awareness can make the difference between a successful mission and a failed mission. The battlefield that our Soldiers are on is dynamic; thus, Soldiers must adapt their information-gathering techniques and fighting styles to tailor to the constantly changing battlefield. A new type of warfare focus has been developed in the age of information to help Soldiers adapt. This warfare focus is called Network Centric Warfare (NCW). Essentially, NCW translates increased information gathering and information superiority into increased combat power superiority on the battlefield. NCW allows commanders to get the most out of their people and assets (Alberts et al. 2000).

Great importance lies in the ability of commanders to present information in the most effective way possible. Too much information can cause a cognitive overload, but enough information is needed to provide situational awareness for effective decision making. This report overviews a preliminary investigation simulating an NCW environment in the form of a simple, yet challenging, war game. The game, titled Shadow Force, requires participants to make decisions based on how the information is visually presented. The results from the simulated game allow us to determine the most effective way to display gathered information to increase information superiority, and thus combat superiority, through NCW.

Shadow Force was based on a game titled Scud Hunt. Scud Hunt was a digital game originally developed by the Defense Advanced Research Projects Agency (DARPA) and ThoughtLink, Inc. to determine how different communication means and visual displays created a shared situational awareness for a mission command scenario within a team (Perla et al. 2000). Scud Hunt used a 5 × 5 square grid to represent the battlefield. Teams of 4 participants were given different types of assets to complete their mission of finding 4 hidden Scud missile-launching devices in a certain number of rounds. The different assets had varying degrees of reliability and did not always provide accurate information. The teams had to use their assets effectively and communicate efficiently to complete the mission of finding all 4 launchers within a specific number of rounds. Shadow Force uses the same play style and concept as Scud Hunt to test a variety of performance variables.

2. Experimental Design

This section describes participants for the experiment, how Shadow Force operates, and what data was analyzed. Prior experimental iterations of Shadow Force were run to test different variables, including different numbers of rounds, different

amounts of time to complete the mission, and varying levels of information being presented (Jackson and Cassenti 2017). The main focus of the current Shadow Force experiment was to see if a visual map-based display using symbols caused a difference in results compared to a text-based situation report.

Participants were randomly assigned either a map-based grid with symbols or a text-based report that would confirm the presence of an enemy launcher, give the possibility of a launcher being present, or deny that an enemy launcher was present through the use of symbols or text. The key research question was: Which information format would generate the highest average number of launcher hits? The number of hits was used as a measure of success to determine which information format was the most efficient.

Approximately 100 participants were recruited online from the Amazon Mechanical Turk service for the Shadow Force experiment. Two different information display methods were used to test which method was more efficient. Half of the participants used only a text-based information display that described if an asset identified no enemy present, a possible enemy present, or a confirmed enemy present for each round (represented as one day) of the game. The other half of the participants used a map-based information display showing corresponding symbols for no enemy, possible enemy, and confirmed enemy on their map. Figure 1 shows the map-based display using symbols. Figure 2 shows the text-based display using a situation report.

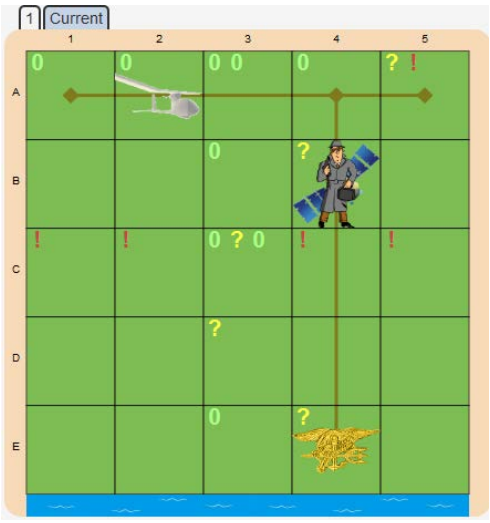

Fig. 1 Screen capture of the map-based information display using symbols

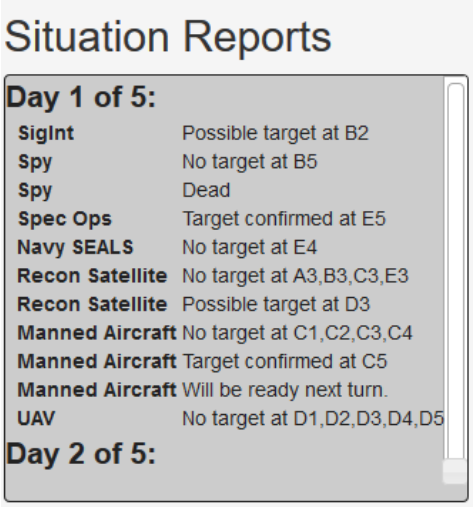

Fig. 2 Screen capture of the text-based display using a situation report

2.1 Gameplay

Shadow Force's gameplay assigns 2 human participants a set of assets. There are 2 different sets of assets: air assets (Satellite, Manned Aircraft, and UAV) and ground assets (SigInt, Spy, Spec Ops, and Navy Seals). Participants are instructed to place their assets within a 5 × 5 grid with the knowledge that each asset performs at a different level of accuracy and reliability. For example, the Spec Ops team asset can be deployed to any one square and can only move one square per turn, but is very reliable in identifying missile launchers. On the other hand, the Satellite asset can scan an entire column, but cannot reliably confirm the presence of a missile launcher. Each participant is able to receive information from their assets at the end of the round, including the other participant's assets. After each round, the information gathered will either be displayed in text form on the situation report, or in symbol form on the grid, depending on which display method the participant was assigned. The participants have 5 rounds (represented as days) to find 4 missile launchers. Each round lasts 150 s. Participants must use their assets in coordination with each other to find all of the launchers. For more detailed information on the instructions for Shadow Force, see Jackson and Cassenti (2017).

The gameplay begins with a brief scenario and background for participants:

> The rogue state of Porona has acquired mobile ballistic missiles and weapons of mass destruction. Porona is threatening our ally, Kartuna, located across the narrow Gulf of Sabani. Your mission is to locate the missile launchers, using various ground, space, air, and intelligence assets. The elite fanatical Poronan Revolutionary Guard Special Artillery Regiment (PRGSAR), with a number of mobile missile launchers, has deployed from its depot to a secret hide site. This deployment is supported by deception operations that may confuse our assets. You must identify

the locations of 4 mobile missile launchers in the next 5 days. The fate of hundreds of thousands of Kartunans depends on your success.

Next, the participants play in a tutorial round where they learn the basics of the game, as show in Fig. 3. The tutorial gives the participants a basic overview of how to play and allows the participants to try different assets. In the tutorial, the participants see both the map-based display and the text-based display. The participants play through 5 rounds with gameplay tips appearing at the top of the screen. For the tutorial, the participants are playing by themselves, but for the actual game they are paired with a human partner who has a different set of assets.

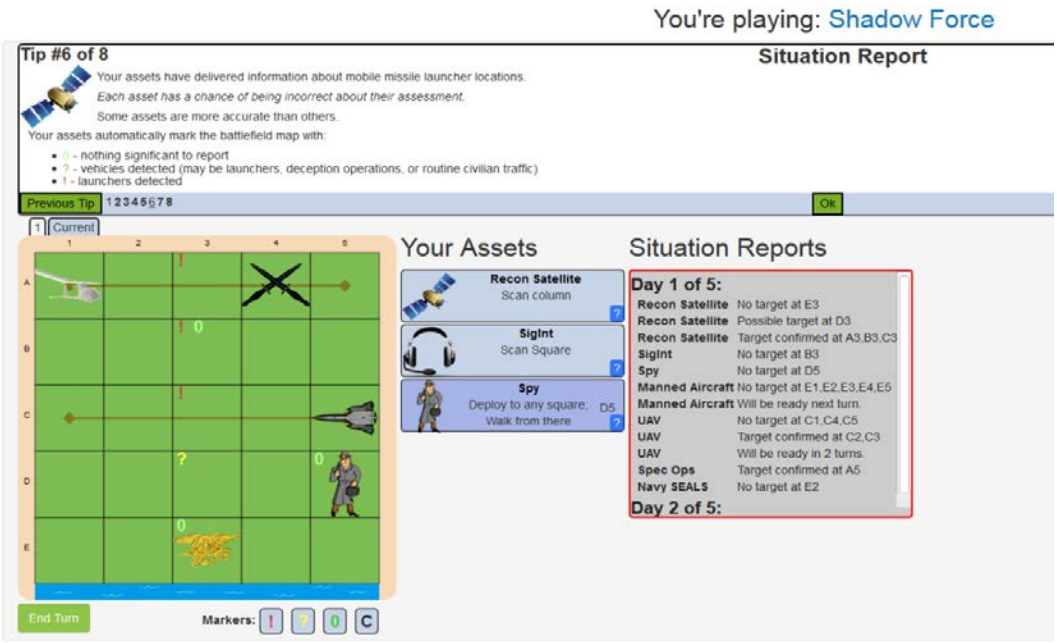

Fig. 3 A screen capture of the tutorial

After the tutorial, the participants are placed into a practice game with a computer partner (a bot). This practice round will randomly assign them a set of assets (air or ground) and one of the display formats (map-based or text-based). Figure 4 is a screen capture of the active map-based display condition during gameplay. In this condition, the situation report only tracks which round (day) the participants are on. The map grid displays the symbols corresponding to the information gathered from both players' assets from previous rounds. Figure 5 is a screen capture of the text-based display condition during gameplay. In this condition, the situation report displays all of the asset information gathered from the previous rounds. The map only displays where the participants are placing their assets for the current round. The display method used in the practice game determines the display method used in the actual game.

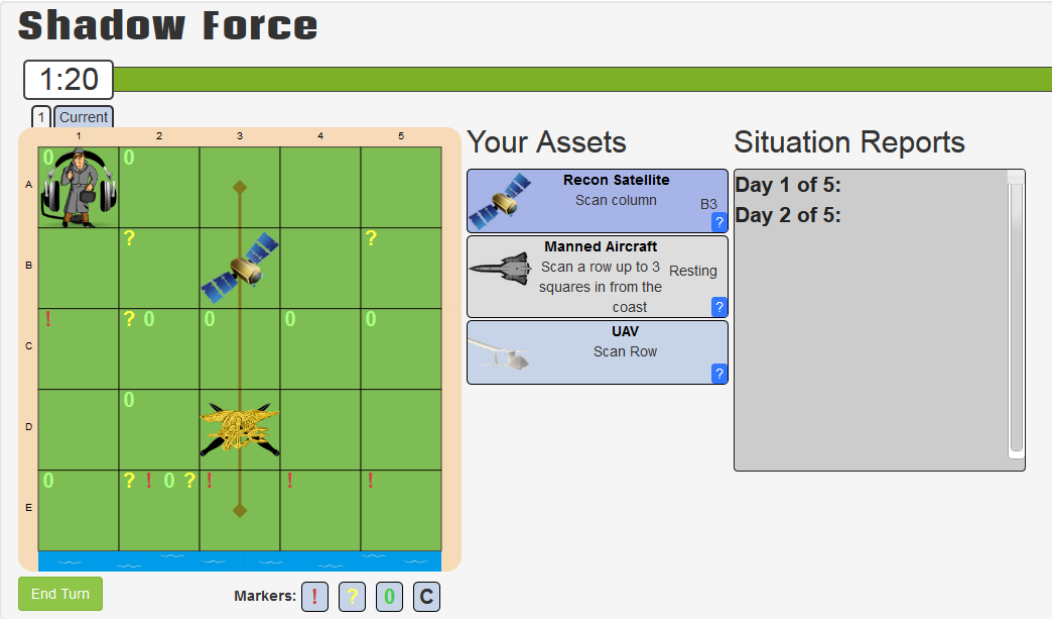

Fig. 4 A screen capture of the map-based display method

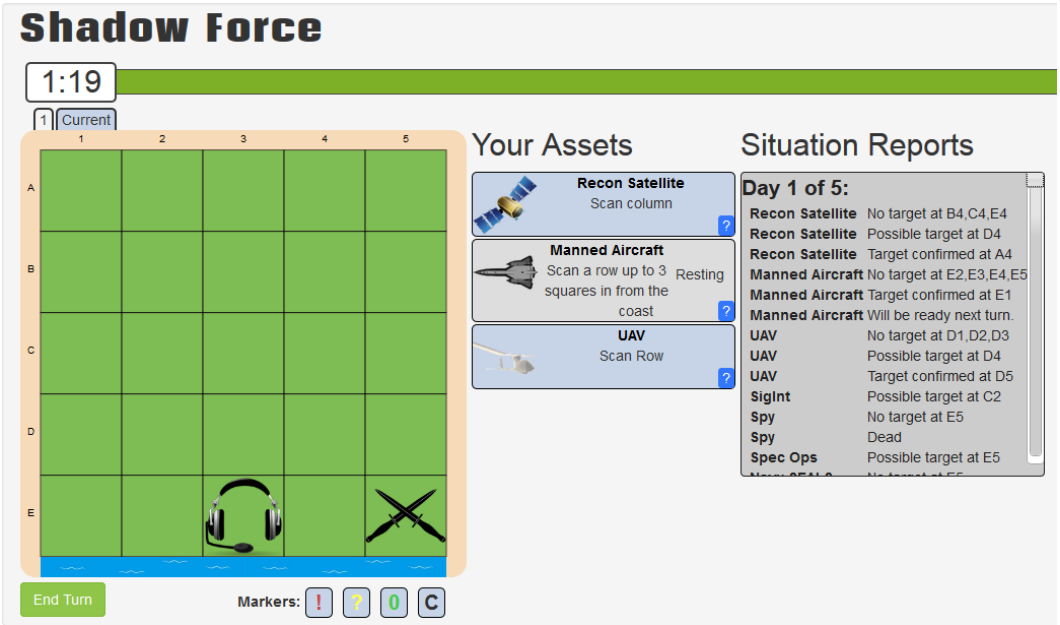

Fig. 5 **A screen capture of the text-based display method**

In the map-based display, the different symbols appear on the grid in the respective squares that were inspected by an asset for each round. The "**0**" represents no target found, the "**?**" represents a possible target, and the "**!**" represents confirmed target. This information is updated at the end of every round. The symbols from previous rounds stay on the map until the game is over.

In the text-based display, each asset gives a description of what was found in the squares they searched (e.g., “No target at E3”, “Possible target at D4”, and “Target confirmed at A4”). The situation report is updated at the end of each round under the day that information was gathered. This information stays in the situation report until the game is over.

After the practice round, the participant is placed in the actual game and paired with another human participant who has also completed the tutorial and practice rounds. Both of the participants are assigned a set of assets (air or ground) and either a map-based or text-based display. Both of the participants use the same information display (e.g., both participants will have a map display or both will have a text display).

The actual game plays exactly like the practice round. After all of the 5 rounds have concluded the participants have 150 s to select where they think the 4 missile launchers are located. The participants have all of the information, including their partners’ information, from all 5 rounds. Participants physically place launchers where they believe the actual launchers are located in the 5 × 5 grid. Figure 6 shows a participant placing their launchers.

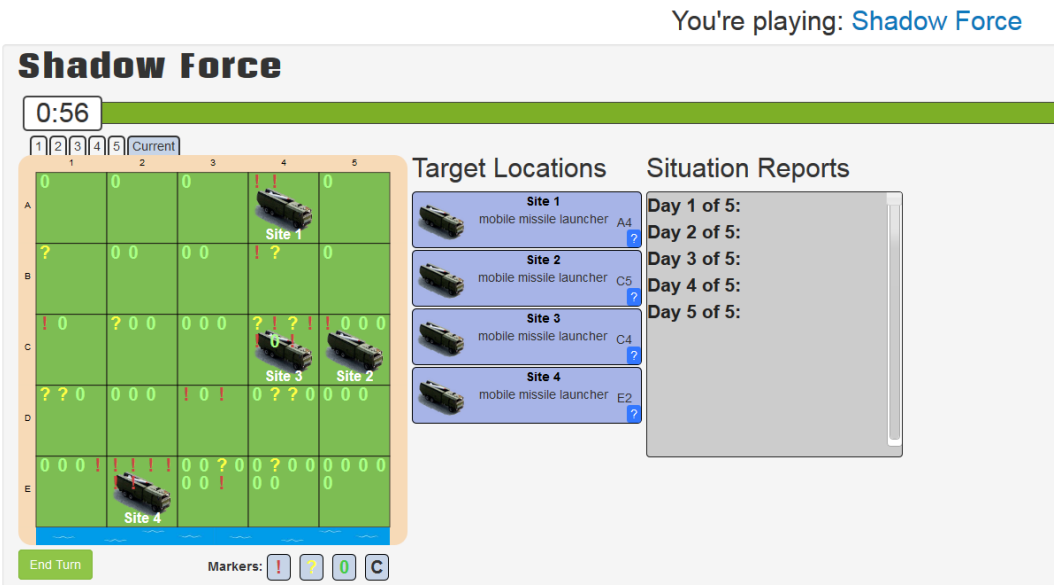

Fig. 6 A screen capture of a participant placing their launchers

Once the participant has placed the launchers, they are asked to rate their confidence of correctly placed launchers based on a Likert-type scale, with responses ranging from “Very unsure” to “Very confident”, as seen in Fig. 7.

Fig. 7 A screen capture of the participant selecting their confidence level

2.2 Post-Game Survey

The post-game survey allows users to reflect on their experience in the game. Questions include:

1. What was your strategy?
2. Did you write down any information reported from the assets for later reference?
3. Rank the assets in the order of most relied upon.
4. Rank the assets in the order of most trustworthy.

For question 1, the participants are given a textbox to freely write how they played through the game. For question 2, the participants are given a yes or no option. For question 3, the participants are allowed to drag and drop the different assets into a list. The asset that the participant relied on the most is put at the top and the asset the participant relied on the least is placed at the bottom. For question 4, the format is the same as question 3, but the participants are told to drag and drop the assets that they believe are the most trustworthy. The most trustworthy is put at the top, and the least trustworthy is put at the bottom.

The results from this survey allow us to evaluate how the participants approached the game, and what type of assets they liked the best.

3. Results

The results from the 100 participants playing Shadow Force allowed us to see which information display was the most effective in improving the participant's situational awareness to complete the mission.

3.1 Analysis

Half of the participants (50) were randomly assigned to the text-based situation report and the other half were assigned to the map-based symbol display. There was a significant difference between the text display and map display in the number of launchers hit: t (198) = 5.95, $p < 0.01$, with the map display hitting more launchers on average. As seen in Fig. 8, the participants using the map-based symbols scored higher (M = 2.35, SD = 1.04) than the participants using the text-based situation report (M = 1.48, SD = 1.03) in terms of missile launchers hit.

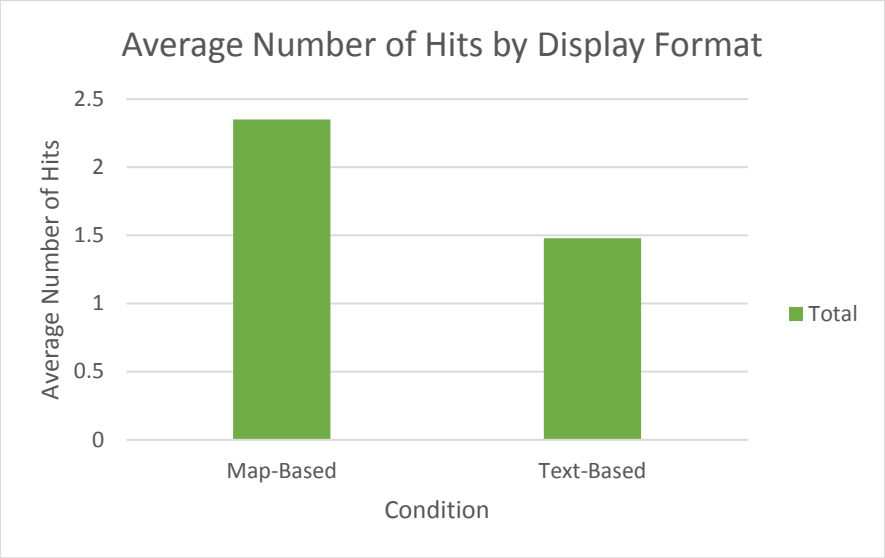

Fig. 8 Shows the average number of launcher hits for each display method

While the map-based display produced better results in terms of targets hit, the level of confidence recorded by the Likert-type scale showed that participants using the text-based situation report were more confident in their selection of possible missile launcher locations. This statistic is surprising, since the map-based participants generally performed better than the text-based participants. There is a significant difference between the map-based confidence and the text-based confidence: t (198) = 1.23, $p < 0.05$. As seen in Fig. 9, the text-based confidence (M = 2.44, SD = 1.03) was higher on average than the map-based confidence (M = 2.26, SD = 0.95).

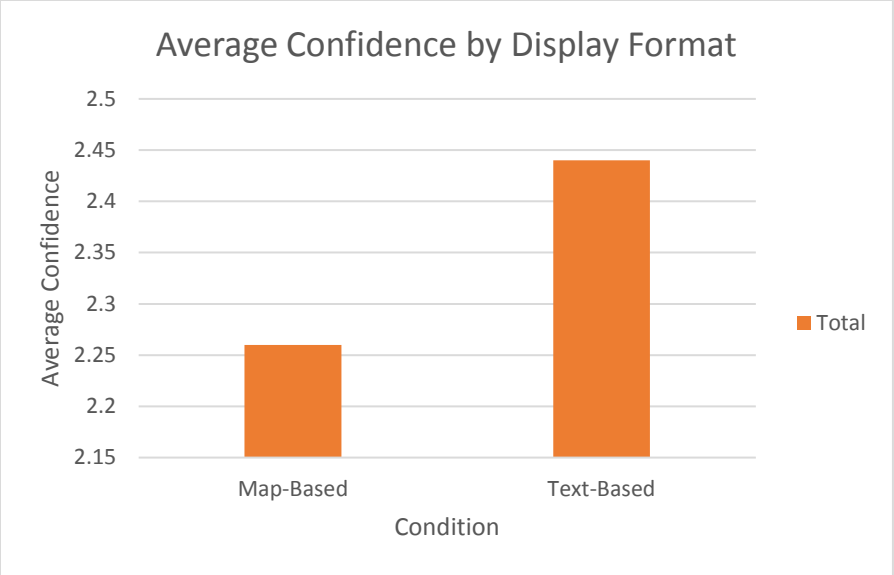

Fig. 9 Shows the average confidence based on which information display the participant was assigned.

While analyzing the confidence levels for each of the conditions, an interesting correlation emerged from comparing the number of launchers hit and the participant's confidence in their choice. The participants who were more confident in their placement of the launchers actually hit fewer launchers than the participants who were less confident. For the participants using the text display, the correlation coefficient was -0.158. This means that, as their confidence increased, the participants hit fewer missile launchers. The map-based participants produced similar results with a coefficient of -0.042. Figure 10 combines the confidence of both map-based and text-based participants into a scatterplot to show total participants' confidence decreased as hits increased. The dots on the scatterplot represent the participants that got those corresponding hits and confidences.

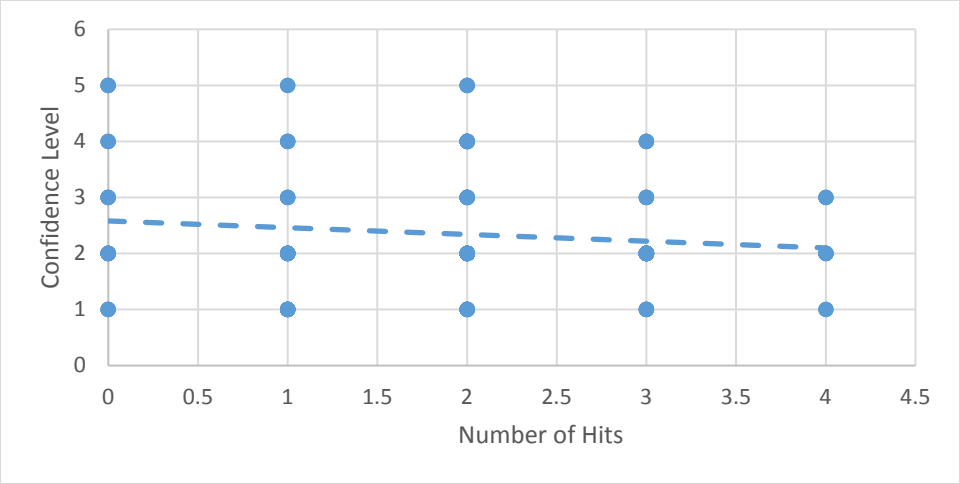

Fig. 10 Shows the declining number of hits for increasing confidences for both conditions combined

3.2 Discussion

On today's battlefield, information is power. NCW says that increased information superiority will translate into increased combat superiority. Our Soldiers need to be able to accurately and quickly identify the information being presented to them. High-quality information will enhance a Soldier's situational awareness and will result in being able to complete the mission more effectively.

When comparing the 2 different displays, the participants with the map-based display had better situational awareness. They were able to complete the mission (locating missile launchers) more effectively. The participants using the text-based display were able to complete the mission, but not as accurately as the participants using the map display. Information overload could have played a role in why the text-based participants scored lower than the map-based participants. The situation report lists all of the asset information collected in a smaller area; therefore, the participant must read every line of text in the situation report. The participants who had the map-based display were able to scan the important information quickly, rather than having to read through an entire situation report.

Overconfidence on the part of the participants using the text-based display is another possible explanation. Participants might perceive that more information is provided in the text-based situation report compared to the map-based symbols. In actuality, the same amount of information was displayed across display formats. The text display may appear as if it shows more data, but it actually uses more working memory to read and comprehend the information than is required by the map display (i.e., scanning symbols on a grid).

Working memory is the part of the memory we rely on to plan and carry out specific behaviors (Cowan 2009). Since the map is using less working memory, the participants are able to make decisions more efficiently than the participants using the situation report, which supports the results from the experiment. Not only did the map participants score more hits, they completed the game in less time with an average time of 162 s. The situation report participants averaged 258 s to complete the game.

4. Conclusion

An experiment in the form of a game called Shadow Force was designed and expanded to investigate 2 information display formats and 2 types of assets. The results from the experiment show information presented using the map-based display format (symbols on a grid) increased situational awareness compared to the text-based situation report. The map-based display resulted in a greater degree of success (time and number of hits) in completing the mission. This could mean that combat effectiveness would be improved if our Soldiers transitioned to a more symbol-based approach to information displays, in accordance with NCW. Shadow Force's data could drastically change the way our Soldiers view information from the battlefield. This display of information could increase information supremacy and accuracy when making life-threatening decisions, and thus could save Soldiers' lives and increase combat effectiveness.

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List of Symbols, Abbreviations, and Acronyms

DARPA	Defense Advanced Research Projects Agency
NCW	Network Centric Warfare
UAV	unmanned aerial vehicle

1 (PDF)	DEFENSE TECHNICAL INFORMATION CTR DTIC OCA
2 (PDF)	DIR ARL RDRL CIO L IMAL HRA MAIL & RECORDS MGMT
1 (PDF)	GOVT PRINTG OFC A MALHOTRA
4 (PDF)	DIR USARL RDRL CII T J SHEVLIN S KASE RDRL CIN S M JACKSON RDRL HRF D D CASSENTI