

MEASURING SHARED AND TEAM SITUATION AWARENESS IN THE ARMY'S FUTURE OBJECTIVE FORCE

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A simulation exercise was conducted to assess the effectiveness of a new Army force structure called Objective Force. This paper will describe how shared and team situation awareness (SA) were measured and analyzed in this experiment with regards to how well the new force structure supports both SA at the individual officer level, within teams and across teams. Shared and Team SA were measured using the Situation Awareness Global Assessment Technique (SAGAT).

INTRODUCTION

During the last few years, the Army has been focused on adapting itself to the rapidly changing strategic and technological landscape of today. Part of this adaptation includes redesigning the current force structure to be more strategically responsive, deployable, agile, versatile, lethal, survivable and sustainable across the entire spectrum of military operations (U. S. Army, 2001). This redesign includes creating a new Brigade (Unit of Action) headquarters staff structure consisting of five main cells: Command Integration, Information Superiority, Fires and Effects, Build and Sustain Combat Power and Maneuver and Support. One concern with the new structure is whether or not it can provide adequate Situation Awareness (SA) to the Commander and his staff officers.

Situation Awareness

Developing and maintaining a highly level of situation awareness (SA) is a difficult part of many Army jobs. It is one of the most critical and challenging tasks in combat today. A vast portion of the warfighter's job is involved in developing SA and keeping it up to date in a rapidly changing environment. This is a task that is not simple in light of the complexity and sheer number of factors that must be taken into account in order to make effective decisions. All of the incoming data from the many systems, the outside environment, fellow warfighters, and others (e.g. civilians and coalition forces) must all be brought together into an integrated whole. This integrated picture forms the central organizing feature from which all decision making and action takes place.

In Army operations, actions occur not just by individuals, but also in teams or units of individuals, which act in concert. While SA is essentially a commodity possessed by the individual (as it exists only in the cognition of the human mind), there is none-the-less much to be gained from examining SA as it exists within teams and between teams that are involved in achieving a common goal. In this light, it is also important to consider the degree of shared SA held by individuals within a team and across teams that must act together. Shared situation awareness is defined as "the degree to which team members possess the same SA on shared SA requirements" (Endsley & Jones, 1997).

A large simulation exercise was conducted at the Battle Command Battle Lab at Fort Leavenworth, KS with the new force structure. This paper will describe how SA was measured in this experiment as well as report on the results from using this measure as it relates to the new force structure. Specifically, did the new force structure support SA at the individual officer level, within teams (cells), and across teams (cells)?

METHOD

Participants

Twenty-five participants, consisting of both active duty officers and retired officers familiar with Brigade level operations participated in this study. These forces were arrayed in five cells per the Army's new Unit of Action force structure:

- Command Integration (CI)
- Fires and Effects (FE)
- Build and Sustain (BS)
- Maneuver and Support (MS)
- Information Superiority (IS)

In addition, data was collected for the UA commander (CO), deputy commander (Dpty CO) and three battalion commanders (CObn), as well as for other detachments. Approximately, 12 other officers participated in supporting roles and were not administered the SAGAT batteries.

SA Measurement

SA was measured using the Situation Awareness Global Assessment Technique (SAGAT). SAGAT is designed to measure an individual's SA at all three levels of SA: perception, comprehension, and projection. The SAGAT measure involves temporarily stopping, or freezing, operator activity (usually in a simulation) and administering a battery of questions that target individuals' dynamic information needs (i.e., their SA requirements) with respect to the domain of interest (Endsley, 2000).

The key to successful SAGAT data collection effort is the validity and appropriateness of the queries for tapping into the key SA requirements of the individual. To develop these queries, we first conducted an analysis of the SA requirements of current Brigade officers through a goal-directed cognitive task analysis (GDTA). The GDTA delineates the goals of each position, the decisions that must be made to achieve these goals, and the dynamic information requirements needed to support the decisions. The GDTAs conducted with officers with brigade command and control experience were used to construct the SAGAT queries (Bolstad, Riley, Jones, & Endsley, 2002).

As a part of the current effort we used the GDTAs to determine the appropriate queries for each officer in the new Brigade (Unit of Action) based on a mapping of the goals of current Brigade officers to the new positions. Table 1 shows the queries assigned to each UA officer. Those queries that were administered to more than one officer represent the SA requirements that need to be shared to provide good shared SA within or between cells. During the freeze each applicable query was presented on each officer's display screen through the SAGAT software. An example of a SAGAT query is shown in Figure 1.

In this study, there were 9 different versions of SAGAT (including different query sets tailored to the positions) developed and administered. However, only the results from 6 versions will be reported here including the Commander and the five staff cells (Command Integration, Fires and Effects, Build and Sustain, Maneuver and Support and Information Superiority). Additionally, there were several SAGAT query sets created for the officers in the Unit of Employment (white cell) as well as the enemy cells. The white cell acted as the higher headquarters (Division) for the Brigade and they controlled the simulation. In this study both the white cell players and enemy cell players acted as the answer keys as real time data could not be recorded from the simulation.

Simulation

The study utilized Army simulation software called OneSAF Test Bed. Three different scenarios were created for the study: low, moderate and high intensity. Intensity varied by the number of simulated enemy units present in the scenario.

Procedure

The experiment consisted of several days of training the new force structure and the simulation test bed. This was followed by a day long planning session and two days of combined simulation execution and planning. The third day of simulation runs lasted a full day.

At random times, the simulation was stopped, all displays were blanked and a battery of SAGAT queries was administered to the participants in the experiment. The query set remained up for three minutes before disappearing. Once they completed answering the SAGAT queries, the simulation was resumed. Participants' answers to the SAGAT queries were compared to ground truth (as taken from the white and

CI	BS	F E	IS	M S	Bn	CO	Query wording
							Indicate the location(s) of each element on the map
							Which units are below green level on ammo?
							Which units are below green level on equipment?
							Which friendly units have been detected by the enemy?
							Which enemy units are currently firing/applying weapons?
							Which friendly units are currently firing/applying weapons?
							What is the force capability of this enemy unit?
							What do you expect this enemy unit to do in the next 10 minutes?
							What is this enemy unit's objective?
							Which friendly units are not able to carry out their assigned tasks?
							What additional assets are needed to carry out your assigned mission?
							Which friendly units need additional fire support?
							Which enemy unit is the highest priority threat?
							How does the status of other Brigades affect your operations?
							How does the status of other Battalions affect your operations?
							How many casualties/wounded has your Brigade suffered?
							How many casualties/wounded has your Battalion suffered?
							Enter the last known location(s) of enemy units/targets which have been destroyed/ rendered ineffective?
							Which friendly units are below green level on overall effectiveness?
							Enter the last known location(s) of friendly units which have been destroyed/rendered ineffective?
							Indicate the current location of supply points on this map
							Indicate potential choke points for your supply routes on the map.
							Which friendly units have had changes to their mission requirements since the original OPORD?
							What additional Intel assets do you need to collect the needed Intel data?
							Indicate the current location(s) of your Intel assets on the map
							Is a change in asset deployment/collection plan needed due to unexpected Intel information?
							Indicate the location of HVT/HPTs on the map.
							Enter the location(s) of known obstacles, including land mines barriers and Concertina wire.
							Which friendly units are outside their maneuver boundaries?
							What is the maximum range of this unit's weapons?
							Currently, which unit has the highest priority with regards to calls for fires?

Table 1. SAGAT Queries Administered to UA Cells

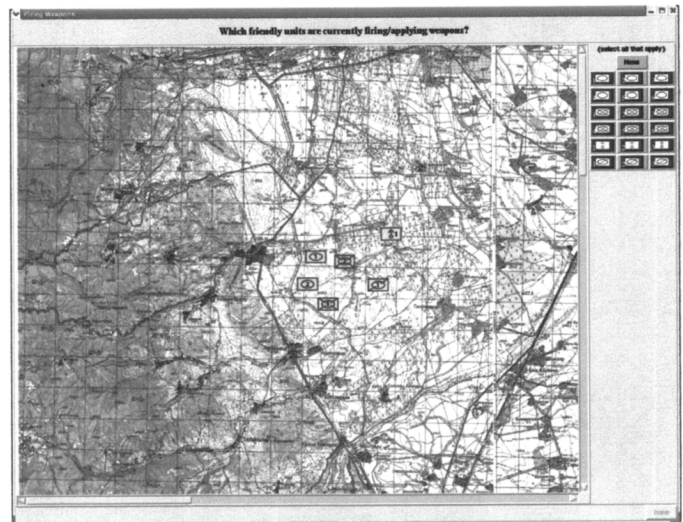


Figure 1. Example of SAGAT Query

enemy cells SAGAT answers), providing an objective measure of the degree to which their perceptions and assessments of the current situation are accurate representations. Additional simulation freezes occurred throughout each trial to obtain a random sampling of participants' SA. As many soldiers were taking part in the

experiment, all participants were given the SAGAT battery at the same time. No communication was allowed between the participants during SAGAT administration, in order to obtain independent assessments of their SA. Throughout the course of each scenario (per day) between 3 and 8 stops occurred to collect SAGAT data.

RESULTS

In order to accurately evaluate participant responses to SAGAT queries, the correct answers to the queries were recorded at the same time the participants were completing the SAGAT battery. The answers were recorded by participants in both the white and enemy cells. Both cells could view the actual state of the battle and all simulation information while completing the answer key. They were given a two-minute warning before a SAGAT stop occurred to help them prepare for the queries. Additionally, the time limit (3 minutes) was not imposed on them.

Responses to the majority of SAGAT queries were scored as either correct or incorrect, based on acceptable tolerance bands. Thus, the data is binomial and a transformation to the SAGAT response measure (e.g., $Y' = \arcsine(Y)$) was applied in order to conduct Analysis of Variance.

Team SA. Team SA is defined as “the degree to which every team member possesses the SA required for his/her job” (Endsley & Jones, 1997). An analysis was performed using both a composite team score for each cell overall as well as team scores for each individual query.

To create a composite score, individual query scores were averaged for each participant for each SAGAT stop. These data were then analyzed using a 3*7 (mission type * cell) ANOVA. (Due to the large number of missing data the SAGAT stop number could not be included in this analysis.) Results revealed that there was a significant cell effect ($F(6,561) = 2.069, p = .055$). As can be seen in Figure 2, the Fires and Effects and Command Integration had the highest overall SA score. On average the Fires and Effects cell was correct 63.3% of the time when answering SAGAT queries and the Command Integration cell was correct 52.2% of the time.

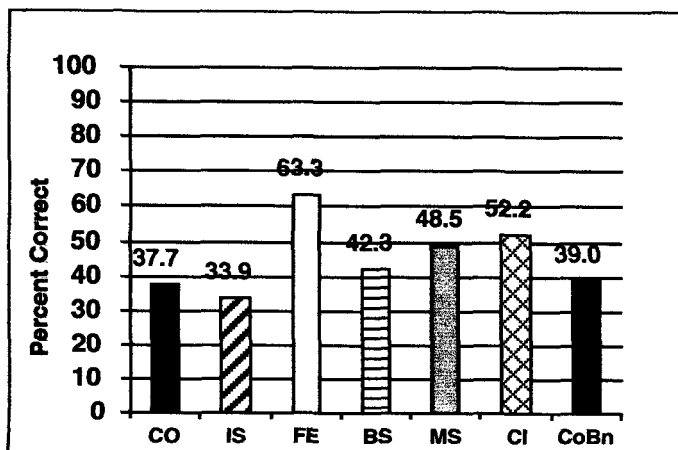


Figure 2: Average Situation Awareness Scores by Cell

Composite SA scores were also created and analyzed for Level 1 versus Level 2 and 3 SA. These SA scores were analyzed using a 3*8*7*2 ANOVA (testing day, stop number, cell and SA level) ANOVA. Results indicated that on average participants had higher level 2 and 3 SA than level 1 SA (see Figure 3) ($F(1,559) = 3.17, p = .08$). Overall, participants answered level 1 queries correctly 42.5% of the time and level 2 and level 3 queries were answered correctly 47.7% of the time. In fact, every cell, except the Build and Sustain and Command Integration cells, answered level 2 and level 3 SA queries correctly at a higher rate than Level 1 SA queries.

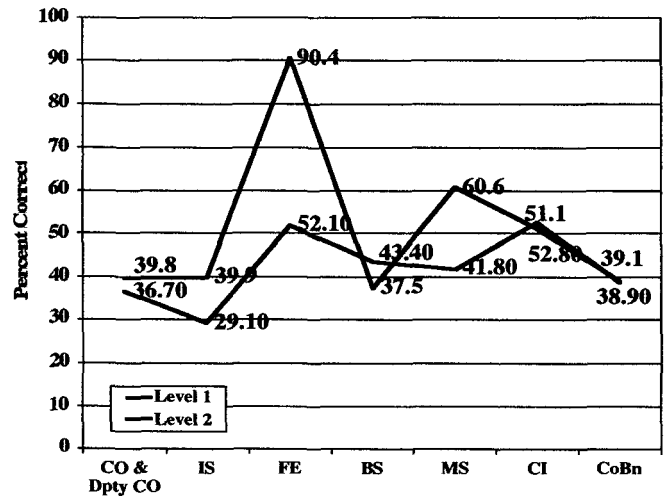


Figure 3: Average Situation Awareness By Level and Cell

In the second analysis, the individual queries were analyzed separately using a 3*8*7 (mission type by stop by cell) ANOVA. Of the 26 queries only 3 had significant cell effects. These significant queries are shown in the table below (see Table 2). While other queries did not show a significant difference between cells, mostly due to small data set sizes, a trend was present indicating the cells had very different SA scores.

What can be inferred from this data is that in spite of the difficulties participants had with the simulation and the collaborative tools available to them or lack thereof, in many instances, the cells were able to process and share SA information. The information that was not being shared across cells at a high level includes: equipment and ammo supply levels (see Figures 4 and 5) and terrain impacts on unit’s ability to carry out their missions. In these instances, one cell had much higher SA for this information than other cells.

Table 2: Queries with Significant Cell Effects

Query	ANOVA
Ammo Level	$F(6,176) = 16.147, p = .000$
Equipment Level	$F(6,112) = 4.625, p = .005$
Terrain Impacts	$F(6,160) = 258.71, p = .004$

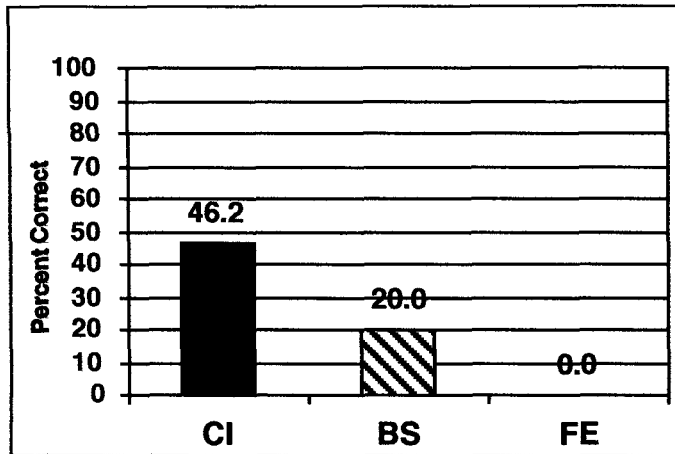


Figure 4: Friendly Units Below Green Level On Ammo by Cell

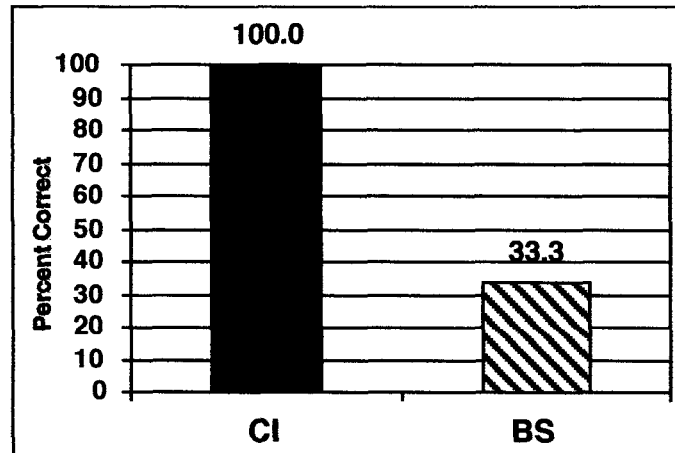


Figure 5: Friendly Units Below Green Level On Equipment by Cell

Shared SA. Shared SA was analyzed by comparing individual participant responses within each cell for each query. The data shows that officers' knowledge of many information requirements varied widely within cells. For example different Command Integration cell members correctly knew which units were below a specified level on ammo: 0%, 33.3%, 50.0% and 100% of the time (see Figure 6). In general most information being measure by SAGAT was not being shared amongst cell members. One reason for this discrepancy was most likely a lack of useful collaborative tools. Problems with the simulation or test participant experience could also have been factors. Only a few pieces of information were being shared consistently within cells. These include: equipment level (CI cell), personnel level (CI cell), enemy intent (MS cell), enemy objective (FE cell), fire support needs (FE cell) and overall unit effectiveness (CI cell).

Commander SA. On way to determine if the Commander is getting sufficient SA is to look at his SA compared to the other participants. In Table 3 the degree to which each query was answered correctly is listed for the Commander and the

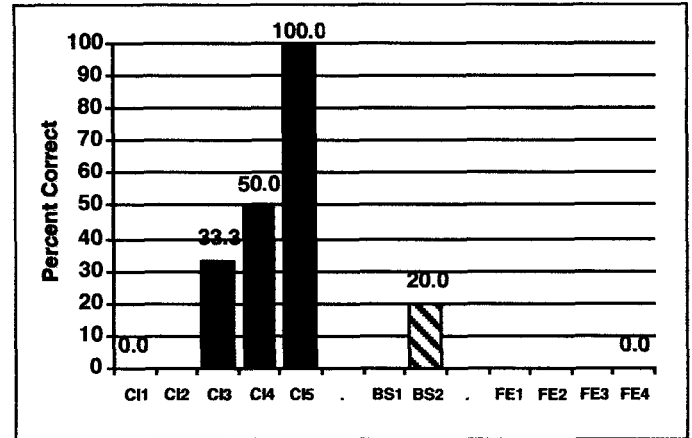


Figure 6: Friendly Units Below Green Level On Ammo by Officers

other participants. As is shown in the table, the Commander's SA was generally lower than the other participants. Of the 12 queries which could be compared across positions, he had lower SA scores on 7 of them. The queries include information about friendly detections, which enemy units are firing weapons, overall effectiveness levels, effect of other units on his operation, which units have difficulties carrying out their assigned tasks and which units have had changes to their mission requirements. On the other hand, the commander was more knowledgeable of the location of friendly and enemy units, which friendly units are firing weapons, enemy's force capabilities, enemy objective's, and the impact of terrain on friendly unit's missions.

Query	Officers Percent Correct	Commander Percent Correct
Map Location	49.0	53.8
Enemy Detections	16.7	12.7
Enemy Firing Weapons	30.4	5.7
Friendly Firing Weapons	23.4	41.5
Enemy Force Capabilities	35.0	43.8
Friendly Effectiveness Levels	71.4	33.3
Enemy Intent	63.6	50
Enemy Objective	40.3	66.7
Assigned Tasks Difficulties	25.0	0
Effect of Other Brigades/Battalion	21.0	0
Terrain Impacts	39.7	78.0
Mission Requirement Changes	66.7	50.0

Table 3: Commander's SA Versus Other Officers

CONCLUSIONS

This study demonstrated one of the first efforts to measure team Situation Awareness (SA) and shared SA in the new Army Force structure, providing a needed foundation for future efforts to evaluate new tools, techniques and procedures in these operations. The results of this study provide some

insight as to the ability of the soldiers to build shared SA both within and across teams. It is one of the first studies to specifically examine team SA in this manner for a large number of individuals, both within and between teams. Results indicated that the measures of SA used in this study was sensitive enough to detect differences in SA in the new force structure.

The results from this study helped to gain a better understanding of SA between and within cells of the new Army force structure. In general, SA was not distributed amongst the cells, demonstrating less than optimal levels of shared SA on information that should have been shared between different positions. It appears that the Command Integration and Fire and Effects cell had the highest SA, while the Information Superiority cell and the Brigade Commander and Deputy Commander had the lowest overall SA. However, this should not be interpreted as a direct reflection on the cell structure alone; rather this also indicates there was a lack of good collaborative tools available for sharing SA between the participants and the cells. Shared SA within the cells was also limited.

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