

# The value of Different Media Types to Support Command and Control Situation Awareness

**Stas Simon Krupenia**

Thales Research & Technology - Netherlands  
stas.krupenia@d-cis.nl

**Cécilia Aguero**

Thales Research & Technology - Netherlands  
cecilia.aguero@d-cis.nl

**Kees C.H.M. Nieuwenhuis**

Thales Research & Technology - Netherlands  
kees.nieuwenhuis@d-cis.nl

## ABSTRACT

We investigated the value of different media types (Photo, Video, Audio) to support the situational awareness of a Command and Control (C2) officer monitoring three simultaneous military operations. Twenty-one Polish soldiers individually monitored the real-time battlefield information collected by three (virtual, scripted) platoons. Twice during the monitoring task a series of Situation Awareness (SA) probes were presented (Endsley, 1995). At the end of the task, participants were also given a series of meta-SA probes and preference questions. We found that Video supported Level 2 SA (comprehension) better than the other two media types. We also found that participants preferred to receive information in the Photos and Audio clips than in Video. We conclude that if the goal of the C2 team is to better understand the global situation, then providing the persons-in-the-field with video cameras is a valid solution. However, we obtained no evidence to suggest that such an approach supports the ability to predict what may occur in the future (Level 3 SA).

## Keywords

Command and control, C2, Situational Awareness, Video, Photo, Audio

## INTRODUCTION

In many large networked socio-technical systems, the information received by a Command and Control (C2) team responsible for monitoring the system is partly or wholly dependent on the information collected by the people in the field (police, fire-fighters). In more technical systems (such as a power plant, or in air traffic, management) the information delivered to a monitoring person or team is based on system parameters and can be somewhat controlled. However, the information delivered to C2 in a 'people-are-sensors' system is more variable. In increasingly networked and advanced socio-technical systems, there is variability in both the kind of information collected by the people in the field, as well as in the mode or method of data collection. For example, Krupenia and Cuizinaud (2011) reported that soldiers completing a virtual reconnaissance mission had a preference for collecting and sending information to C2 in the Photo, Video, and Audio media types (in declining order of preference) while mostly ignoring the option of sending text or placing iconic cues on a digital map. Given the variability in the kind (content and mode) of information received by a C2 team in systems that include people-as-sensors, there are many opportunities for system monitors to lose gain or lose overall awareness of the situation (Situational Awareness). The goal of the current study was to examine how Situational Awareness of a C2 mission monitoring officer is affected by different data collection methods of the field operators (soldiers). For the current research, and consistent with Endsley (1995) Situational Awareness was defined to include three levels; Perception, Comprehension, and Projection (prediction) and was measured using series of SA probes developed consistent with the SA Global Assessment Technique (SAGAT; Endsley, 1988). SAGAT has been previously found to be a valuable tool for measure SA in C2 situations (Salmon et al., 2007). It is difficult to apply traditional research investigating multimodal information cues for supporting SA (e.g. Hale, Stanney, Milham, Carrol, & Jones, 2009), because these studies typically investigate multimodal alerting cues conveying only very basic information (e.g. turn left/right, move faster/slower...). In light of this absence of existing literature, we consider the current research exploratory.

## METHODS

### Design

Participants were tested individually. Each participant played the role of a Command and Control (C2) officer monitoring three simultaneous (simulated) platoon operations from a battalion operations room where each platoon communicated using a different media type; Photo, Video, or Audio. These media types were selected because Krupenia & Cuizinaud (2011) found them to be the most-used options when soldiers completed a reconnaissance mission using a multi-media data collection tool. In the current study the participants' goal was to monitor the three operations as they would in a normal C2 room. During the monitoring task, each platoon sent ten pieces of information to C2 and on two occasions the participant's SA was probed.

### Participants

Twenty-one Polish soldiers participated in the experiment. Participants had an average of 19.8 years of military experience (SD= 3.37) and were of ranks Captain (5), Major (13), Lieutenant (2), and Lieutenant Colonel (1). The participants were mostly conformable with computers (three people were somewhat comfortable, 12 were comfortable, and 6 were very comfortable) as well as with technology in general (2 were not very comfortable, 2 were somewhat comfortable, 13 were comfortable, and 4 were very comfortable). Sixteen participants were from the army and five were from the air force.

### Operation Descriptions

The three different platoon operations were scripted. Each platoon was conducting a social patrol within an area of Honiara (Solomon Islands). The platoon scripts were constructed by the research team in a deliberate way to maximize the opportunity of the participant to distinguish between their courses of operations. Additionally, they were constructed so that the events portrayed in the developing story line were plausible and the storyline predictable (that is, if reading the full text of the script). Each platoon encountered ten events and the operations lasted thirty minutes. The three operations, 'Do Nothing', 'Defend', and 'Retreat' are described below. In 'Do Nothing' the platoon was preparing to defend a government building. The platoon patrolled the perimeter and obtained information about potential threats. The platoon circumnavigated the building and observed friendly and helpful people. During this operation, the patrol encountered several normal events such as people chatting, kids, and a crowded market. In 'Defend' the platoon conducted a social patrol through an outer part of the city. During the operation, the patrol observed an attack on a police building. The attacker, who has a personal vendetta against the police, fired shots towards the police station, but with no intent to kill or injure anyone. The attacker surrendered to the police. The platoon did not interfere but was required to take cover when the shots were fired. In 'Retreat', the platoon moved through urban terrain to gain an understanding of a potential enemy. As the operation progressed, it was clear that the soldiers are moving through a hostile area. Towards the end of the operation, the platoon encountered a road block (burning bus), and then decided to retreat to a safer location.

### Questionnaires

Three questionnaires were administered, a Demographics Questionnaire, an SA Questionnaire, and a Debriefing Questionnaire. The pen-and-paper Demographics Questionnaire was used to obtain information about age, nationality, years in military, rank and specialization, handedness, languages spoken, comfortableness with computers, internet usage, comfortableness with technology in general, and education.

The pen-and-paper Situation Awareness Questionnaire was administered twice, after the third and seventh events, during which the operations were paused. At both times, participants were required to answer all SA questions for all three missions as quickly and accurately as possible. The full questionnaire included ten SA probes which were constructed using prior similar probes (Strater, Faulkner, Hyatt, & Endsley, 2006) as well as via discussions with current military personnel. In the current study we present an analysis of the following three SA probes:

1. How do the last three events relate? (Select from: they are unrelated, two of the three events are related, or all three events are related)—probes level 2 SA (Comprehension)
2. Will the operation continue as planned? (Yes/No)—level 3 SA (Projection)

3. Which kind of task will the platoon need to engage in within the next short time period (5-15 minutes)? (Select from: Attack, Move, Defend, Retreat, Nothing)—level 3 SA (Projection)

The Debriefing Questionnaire was delivered electronically using a Microsoft Excel™ spreadsheet. The questionnaire was used to assess the participants' meta-awareness of their situation awareness according to media type, their overall media preferences, and the perceived realism of the simulated operations. In total seven multiple choice questions and one open-ended question was presented. Of particular interest were responses to three meta-SA questions; (1) did you perceive properly the events that occurred in the missions? (2) Did you understand what was happening in the mission? (3) Were you able to project (predict into the future) what was going to happen in the mission? To complete this questionnaire, participants placed an "x" next to the answer they thought was most correct for each question. For the three meta-SA questions, the five response options were: Very Good, Good, Reasonable, Poor, and Very Poor. For the media type preference question, participants rank ordered their preferences from 1 to 3 and for perceived realism, the five response options were: Very realistic, Realistic, Neutral, Unrealistic, and Very Unrealistic.

### Monitoring Tool

The monitoring tool was built within Google Earth. As the missions progressed, participants saw a growing blue 'snake' representing the trajectory of the platoons (see Figure 1). As new data was collected by the platoon, a new icon appeared on the monitoring tool; a "P" icon for a Photo, a "V" for Video, and an "A" for Audio. Participants interacted with the monitoring tool in the same way that they would interact with Google Earth. To view the collected data, the participant clicked on the icon and the media was presented in an embedded player. Once data was sent to C2, participants could view that data as many times as they wanted. All the data that was presented to the participants was previously constructed by the research team (see Operation Description above) and was collected within the virtual military environment Virtual BattleSpace 2 (VBS2 © Bohemia Interactive).

To construct the data set, a video of each event was created in VBS2 that logged the GPS coordinates to the real map and created a new video at that location. The video included virtual sounds generated from VBS2. For the Photo condition, a frame of this video was extracted. For the Audio condition, the VBS2 audio was retained and was superimposed with a short text audio commentary of the event. This commentary was constructed by the research team and aimed at given an objective description of the events shown in the video (in the same way that a soldier may verbally describe an event that they have witnessed).

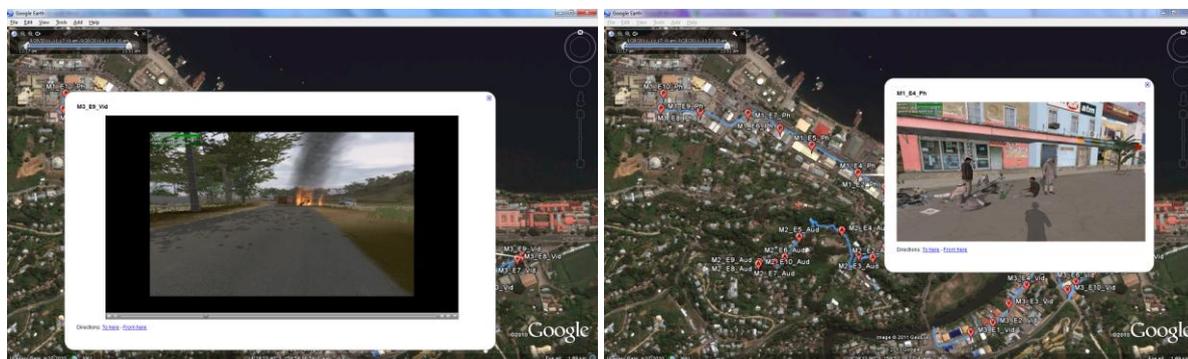


Figure 1. Screen of Monitoring Tool for Platoon 3, Event 9-video (left) and Platoon 1, Event 4-photo (right).

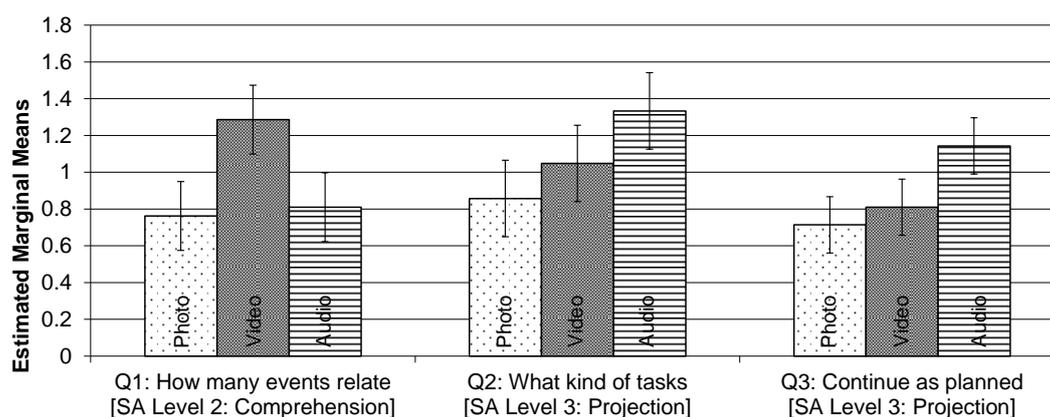
### Procedure

Upon arrival at the experiment room, participants were welcomed and the experimenter introduced themselves to the participants. The participant was then provided with an information and consent form. Once consent was obtained, the general experiment instructions were read to the participant. Participants then completed the Demographics Questionnaire. Next, the Monitoring Tool was explained to the participant. A training scenario was used to explain how the participant could access and review the incoming information. Participants also had time to practice interacting with the Monitoring Tool. When they felt comfortable with the technology, the experiment began. After the third and seventh events for each platoon had been presented, the monitoring task was paused and the SA Questionnaire was given. At the end of the monitoring task (about 55 minutes which including breaks for the SA Questionnaire), the participants were given the Debriefing Questionnaire. Finally, participants were thanked for their time and given a small gift.

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## RESULTS

Data was analyzed using PASW Statistics 18 (© IBM). The analysis of the SA Questionnaires was conducted using data from 18 participants. The data from three participants was removed due to an error in the printed questionnaires. To score answers to the SA probes, correct answers were awarded with one point and incorrect answers with zero points. For all three SA probes, a repeated measures analysis of variance ( $m$ ANOVA; repeated covariance type: AR1) was conducted to test for effects across Media Type and participants with Media Type (3 levels) as fixed effects and Participants as a random effect. A summary of the results for SA Probes 1 to 3 is presented in Figure 2 which shows the Estimated Marginal Means (and Standard Error Bars). In response to the question, “How many of the last three events relate?” we observed a difference between Media Types that was leaning to significance (Tukey, 1969;  $F(2) = 2.850, p = 0.068$ ) with Video cues triggering the most number of correct answers. For the second and third questions we failed to identify a significant effect of Media Type ( $F(2) = 1.403, p = 0.261$  and  $F(2) = 1.570, p = 0.219$ , respectively).



**Figure 2. Estimated Marginal Means for answers to SA Probes for three Media Types (including Std. Error bars)**

From the Debriefing Questionnaire, participants felt that they maintained a fairly good awareness of the operations. Half the participants ( $N=9$ ) said they maintained ‘Good’ awareness, one person had ‘very good’ awareness, five were ‘reasonable’, two were ‘poor’, and one was ‘very poor’. For the three meta-SA questions, an  $m$ ANOVA (repeated covariance type: AR1) was conducted to test for effects across media type and participants with Media Type (3 levels) as a fixed effect and Participants as a random effect. The  $m$ ANOVA failed to identify a main effect of Media Type for any probe ( $F(2) = 0.025, p = 0.0976$ ;  $F(2) = 1.679, p = 0.201$ ;  $F(2) = 1.924, p = 0.164$ ). An additional  $m$ ANOVA was conducted to examine user preferences for the different media types. Results indicated an overall effect of Media Type ( $F(2) = 14.110, p < .001$ ) with Photo and Audio being significantly more preferred than Video (Photo vs. Audio,  $ns$ ; Photo vs. Video,  $p < .005$ ; Audio vs. Video,  $p < .001$ ). In general, participants found the scenarios mostly realistic: six participants rated the scenario “Very Realistic”, nine rated them “Realistic”, one person was “Neutral” and two people thought the scenarios were “Unrealistic”. No participants rated the scenarios “Very Unrealistic”.

## DISCUSSION AND CONCLUSION

There are two main findings from the current research. First, it appears that of the three media types used, Video best supported Level 2 SA, comprehension. Two explanations for this finding are presented. First, compared to the other media types, Video provided a richer and broader source of information. This broader view appeared to have helped participants identify the commonalities between the different events. By accessing seemingly peripheral information that was not pertinent to the intended event, participants appeared better able to identify links between information. Second, the richer sensory environment afforded by Video coupled with the active searching for information likely supported better memory encoding compared to the other media types ( Craik & Tulving, 1975; Gopher, Krupenia, & Gavish, 2010). Indeed, an important aspect of Comprehension is recall. Only by recalling and comparing previous events could participants make a judgment on their relatedness. This result is consistent with Durso, Bleckly, and Dattel (2006) and Endsley (1995) who suggested a strong relationship between memory and SA.

The second finding was that participants preferred to receive Photos and Audio information than Video. One explanation is that it was arguably easier to identify the main component of the event with Photos and Audio

than with Video. Consistent with the earlier discussion, when participants received Video they had to actively search these cues for the pertinent information. With Photos and Audio, there was less information delivered, and thus extracting key information was easier. Thus the rationale for why participants preferred Photos and Audio is consistent with the earlier discussion explaining why Comprehension was better using Video. We conclude that Video appeared a useful way for supporting C2 to attain a good understanding of the global situation. However, because this media type was not well liked (most likely due to the cost involved in processing this data), such media may need to be used sparingly. Additionally, we found no evidence to suggest that Video supported projection.

A limitation in the current work was in creating a realistic virtual environment some aspects of the research lacked experimental control. For example, the total information available in the different media types was not equal (e.g. Video appeared most informative and contained much peripheral information)—however, different media types will never be equal when a multi-media data collection tool is used in a realistic way. Additionally, given the argument made about memory supporting SA, no record was made of the number of times participants accessed the data for each event. In future work we plan to examine the remaining set of SA probes. Future research should examine the relationship between the variability in incoming data and the implications of this on situation awareness. Finally, it would be valuable to know which combinations of media types would best support Level 3 SA, Projection.

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