

## **TOOLS FOR SUPPORTING TEAM SA AND COLLABORATION IN ARMY OPERATIONS**

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### **ABSTRACT**

*Situation awareness (SA) plays an important role in Army operations. Within the future Objective Force, considerable effort is being directed at developing tools to improve SA for individual soldiers and for supporting shared SA and collaboration across teams. Little guidance exists as to which tools are appropriate for collaborative tasks or situations. The present paper presents a taxonomy of collaboration and, based on this taxonomy, information is provided on which classes of collaborative tools and techniques are most useful to the Army for different types of tasks and situations.*

### **INTRODUCTION**

Situation awareness (SA) plays an important role in Army operations. While the term SA has received considerable attention, very little effort has been directed on how to improve SA for soldiers. One way to support sharing of SA is through the use of collaborative tools and techniques.

While the Army uses a variety of collaborative tools, a review of these tools in terms of the Army's need for sharing SA has not been conducted. The present paper reviews current collaborative techniques and evaluates their ability to support shared SA within the context of distributed Army. While the number of collaborative tools is immense, the types of collaboration techniques they employ are much smaller. This review does not strive to review all tools, but rather to identify and review specific collaborative tool types.

The evaluation of these tools was conducted through the development of taxonomy of collaboration. The taxonomy was created to describe the different types of collaboration techniques and tool characteristics that are needed to support the differing types of collaboration.

### **COLLABORATIVE TOOLS**

A number of different tools or devices can be considered for supporting collaboration across command and control teams. Categorically, these tools include: face-

to-face, video conferencing, audio conferencing, telephone, networked radio, chat/instant messaging, white board, file transfer, program sharing, email, groupware, bulletin board and domain specific tools. These categories are not exhaustive but represent the more common tool categories. It should be noted that many different special purpose and COTS products are available in each of these categories, and may encompass devices in multiple categories.

#### **Face-To-Face**

The currently idealized collaboration environment occurs when individuals are collocated in the same room communicating face-to-face. Face-to-face collaboration also encourages social interactions between individuals or small groups as well as private conversations between people. One important feature of the collaboration process is the use of social cues to determine behavior and assess the acceptability of decisions. These social cues include facial expressions, body language, silences and what is explicitly said. Although, studies have shown that face-to-face meetings may not be as efficient as meetings using other collaborative techniques (Lantz, 2001), face-to-face collaboration can be regarded as the baseline or control condition against which other collaborative techniques can be compared.

#### **Video Conferencing**

Video conferencing involves using a computer network between two or more participants at different sites to transmit audio and video (images and text) data on a computer monitor in a conferencing format. For example, a point-to-point (two-person) video conferencing system works much like a video telephone. Each participant has a video camera, microphone, and speakers mounted on his or her computer. As the two participants speak to one another, their voices are carried over the network and delivered to the other's speakers, and whatever images appear in front of the video camera

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appear in a window on the other participant's monitor. Multipoint videoconferencing allows three or more participants to sit in a virtual conference room and communicate as if they were sitting right next to each other (Webopedia, 2002). Obviously, the number of participants and screens that can be viewed at any one time is limited by both the bandwidth and hardware that is available. Typical video conferences limit the number of viewable participants to four.

### **Audio Conferencing**

An audio conference, also known as a teleconference, is a meeting among two or more participants who are connected over a network (Internet or Intranet), telephone or satellite link in real time and can communicate by voice and fax (Computeruser, 2002). At its simplest, a teleconference can be an audio conference with one or both ends of the conference sharing a speakerphone. With considerably more equipment and special arrangements, a teleconference can be a conference with multiple participants actually appearing to be in the same room together (Tech Target Network, 2002). One drawback to very large conferences is the inability to identify who is talking at any one time.

### **Telephone**

A telephone connection can be considered a simple form of an audio conference. However, audio information is only transmitted via a telephone or satellite link instead of a network. Traditionally, telephone conferences were limited with regards to the number of participants that could be included, but this is no longer the case. Telephone conferences can support over a hundred individuals at any one time. Like audio conferences, the inability to identify who is talking is a problem.

### **Networked Radios**

Networked radios are frequently used in military operations to create a dedicated verbal communication system for multiple team members in distributed locations. Unlike telephones, these communications networks are generally "always on", although different people may join and leave the network at different times.

### **Chat/Instant Messaging**

Chat or instant messaging is real-time communication between two users via computer in which written text based notes are recorded and messages are sent in real time. Typically, the instant messaging system alerts you whenever somebody on your private list is online. You can then initiate a chat session. Once a chat has been initiated, either user can enter text by typing on the

keyboard and the entered text will appear on the other user's monitor (Webopedia, 2002). There are several competing instant messaging systems. Unfortunately, there's no standard, so anyone you want to send instant messages to must use the same instant messaging system.

### **White Board**

White boards are typically a space on the display in which one or more participants write or draw, using a mouse, keyboard, or other input device. They are used for exchanging graphics and diagrams. An electronic whiteboard (also called a smartboard) is one of several kinds of writeable presentation display systems that can be used in a classroom or videoconference. These whiteboards generally fall into one of three categories: standalone copy boards, where the content of the whiteboard can be scanned and printed out; peripheral boards, which transfer information in the form of digital files to an attached computer; and interactive boards, the most expensive and sophisticated option, which are like large touchscreen monitors that can be synchronized to an attached computer -- users can interact with the display, visit Web sites, and access databases directly from the board. There are a number of add-on whiteboard digitizer products available that can be used to make traditional dry-erase whiteboards interactive (Tech Target Network, 2002).

### **File Transfer**

File transfer is the movement of one or more files of data or information from one computer location to another (Webopedia, 2002). These electronically-stored files can be moved by sending the files over a telecommunications medium. On the Internet, the File Transfer Protocol (FTP) is a common way to transfer a single file or a relatively small number of files from one computer to another. For larger file transfers (a single large file or a large collection of files), file compression and aggregation into a single archive, such as a zip file, is commonly used (Tech Target Network, 2002). The ability to perform file transfers is included in many of commonly used collaborative tool suites, such as Microsoft NetMeeting. Using these collaborative tools, participants can transfer files in background during a collaborative meeting.

### **Program Sharing**

Program or application sharing enables conference participants to simultaneously run the same application. The application itself resides on only one of the machines connected to the conference and the individual who owns the application (it is on their computer) gives

control of the program to the other participants (Webopedia, 2002). This is a feature in many collaborative tool packages, such as Microsoft NetMeeting and First Virtual Communication's Click to Meet. During program sharing the participants can all view the package at the same time, but only one participant can be interacting with it at a time.

### **Email**

Email is short for electronic mail, which is the transmission of messages over computer networks. Most e-mail systems include a rudimentary text editor for composing messages, but many allow the user to edit their messages using any editor and paste the message in the email. The user then sends the message to the recipient by specifying the recipient's address. The same message can also be sent to several users at once called broadcasting (Webopedia, 2002). Sent messages are then stored in electronic mailboxes until the recipient fetches them. After reading the mail, the recipient can store it in a text file, forward it to other users, or delete it.

### **Groupware**

Groupware, also sometimes referred to as group support systems (GSS,) uses computer technology to support group activities. They are designed to facilitate two or more users working on a common task in a shared environment by providing mechanisms for coordinating each user's actions with respect to the group and the system (Krasner, McInroy, & Walz, 1991). According to Nunanmaker (1997), group support systems (GSS) encompass a set of techniques, software and technology designed to focus and enhance communications, deliberations, and decision making of groups. His research has shown that teams using group support systems become more productive and often reduce their time and labor costs required to produce a project. Unlike other methods of computer based collaborative techniques, GSS uses more structured processes for facilitating decision making and generating and prioritizing alternatives, building consensus and establishing plans. Insufficient flexibility is a major problem for groupware (Grudin, 1999). Thus, unstructured and free flowing collaboration is not supported well by these tools.

Many groupware tools are created from existing commercial software programs (Grudin, 1999). For example, a meeting scheduler integrates a collaborative calendar function with email and is classified as groupware. Another commonly used groupware tool is Lotus Notes, which integrates email with information sharing. One example of a groupware product used in

some U.S. Army facilities is Group Systems. This tool allows users the ability to enter information on predefined topics (buckets) and the ability to sort and prioritize these buckets of information.

### **Bulletin Boards**

A bulletin board system (BBS), is a tool that exists for the purpose of sharing or exchanging messages or other files. Essentially, a bulletin board system is a host computer that is accessible by dial-up phone (you need to know the phone number) or, at some sites, via Telnet. Bulletin board systems originate and generally operate independently of the Internet. However, many BBS's have Web sites.

### **Domain Specific Tools**

The tool types reviewed above are general purpose collaborative tools — they allow the transmission of a wide variety of different types of information. Domain specific tools, on the other hand, work to transmit very specific information, tailored to the information transmission needs of particular individuals. For example, rather than using a phone or email to convey the location of a detected target, a domain specific tool would transmit that information from one person's displays to another's (often through a common database) any time that such a detection occurred. Such tools are generally customized to fit the information requirements of specific team tasks and information sharing needs. They are generally much faster, but less flexible than general purpose collaborative tools.

## **COLLABORATIVE TOOL TAXONOMY**

The collaboration matrix consists of several sections rating the degree to which these different categories of collaborative tools support different types of collaboration characteristics, tool characteristics, information types, and processes. The taxonomy, presented in Tables 1, 2 and 3 was developed as a method for determining which tool category best supports the needs of the individual collaborative environment for different classes of operations.

### **Collaboration Characteristics**

Important characteristics of the type of collaboration to be supported by the tools includes:

- **Type of collaboration** – whether the individuals will be collaborating at the same time (synchronously) or asynchronously.
- **Predictability of collaboration** – whether the collaboration will occur at a previously scheduled and predictable time, or at unscheduled unpredictable times.

- **Place of collaboration** – whether the collaboration will involve individuals who are co-located or distributed.
- **Degree of interaction** – whether the collaboration will require simple one-way communications or a great deal of back and forth interactivity.

As shown in the taxonomy (see Table 1), face-to-face, video conferencing, audio conferencing, program sharing, telephones and radio communications all require fairly synchronous collaboration, while white boards, file transfer, email, bulletin boards, group ware and domain specific tools allow for asynchronous collaborations. Face-to-face communications, video conferencing, audio conferencing and groupware have traditionally required a fair degree of pre-scheduling, although if cost is not an issue, “always on” technologies could provide unscheduled access to collaboration through these mechanisms. Other mediums provide the advantage of allowing unscheduled collaboration to occur fairly readily.

Tool Category	Collaboration Characteristics			
	Time	Predictability	Place	Interaction
Face-to-Face	Synchronous	Scheduled or Unscheduled	Collocated	High
Video Conferencing	Med-High synchronicity	Scheduled or Semi-scheduled	Distributed	Medium-High
Audio Conferencing	Med-High synchronicity	Scheduled or Semi-scheduled	Distributed	Medium-High
Telephone	Med-High synchronicity	Unscheduled	Distributed	Medium-High
Net Radio	Med-High synchronicity	Unscheduled	Distributed	Medium-High
Chat/Instant Messaging	Med-High synchronicity	Semi-scheduled or Unscheduled	Distributed	Medium-High
White Board	Synchronous or Asynchronous	Scheduled or Unscheduled	Distributed or Collocated	Moderate
File Transfer	Asynchronous	Unscheduled	Distributed or Collocated	Low
Program Sharing	Synchronous	Scheduled	Distributed or Collocated	Moderate
Email	Asynchronous	Unscheduled	Distributed or Collocated	Moderate-Low
Groupware	Synchronous or Asynchronous	Scheduled or Semi-scheduled	Distributed or Collocated	Moderate
Bulletin Board	Asynchronous	Unscheduled	Distributed	Moderate
Domain Specific Tools	Synchronous or Asynchronous	Scheduled or Unscheduled	Distributed or Collocated	Low

Table 1. Taxonomy of Collaboration – Part 1

While face-to-face is singularly good at providing a high degree of interactivity in collaboration, other technologies fare less well on this criterion. Video conferencing, audio conferencing, telephone and radio provide fairly high interactivity, although not generally as much as face-to-face communications, in that subtle cues regarding when the other person will speak tend to get lost, leading to problems with talk-overs and lags between speakers. This is particularly a problem with larger groups and when significant communication lags are present.

### Tool Characteristics

There are also certain characteristics of tools that affect the types of collaborations that can take place (see Table 2).

Tool Category	Tool Characteristics		
	Recordable /Traceable	Identifiable	Structured
Face-to-Face	No	High	Unstructured
Video Conferencing	Possible	Moderate	Unstructured
Audio Conferencing	Possible	Poor	Unstructured
Telephone	Possible	Good	Unstructured
Net Radio	No	Poor	Unstructured
Chat/Instant Messaging	Moderate	Good	Unstructured
White Board	Moderate	Moderate or Good	Unstructured
File Transfer	Good	??	Unstructured or Structured
Program Sharing	Possible	??	Unstructured or Structured
Email	Good	Good	Semi-structured
Groupware	Good	Yes or No	Semi-structured
Bulletin Board	Good	Yes or No	Semi-structured
Domain Specific Tools	Low	Poor	Structured

Table 2. Taxonomy of Collaboration – Part 2

- **Recordable/traceable** - Some tools provide traceability of the collaborations that can be drawn upon for creating an audit trail or for bringing missing team members up-to-date.

- **Identifiable** – Tools also can vary in terms of the degree to which they allow for the individuals using them to be reliably identified by others involved in the collaboration.
- **Structured** – Tools vary in terms of the degree to which they allow for structured communications (of a very specific predetermined nature) or unstructured communications (allowing a wide variety of information types to be exchanged).

While face-to-face communications are seen as very good for collaboration, they do not generally provide traceability (unless separate recording devices are employed). File transfer, email, groupware and bulletin boards, by comparison incorporate built in traceability. White boards and instant messaging also provide traceability, at least for short periods of time. While face-to-face communication provides a high level of identifiability, this can be more of a problem with other systems. For instance being able to tell who is speaking can be difficult on teleconferences or group radios. Identifiability is generally good with instant messaging, white boards and telephones.

Groupware and bulletin boards may or may not provide identifiability, depending on the system and predefined options. An advantage of many collaborative tools is the wide variety of unstructured communications that they can support. Domain specific tools support primarily very structured communications

**Information Types**

The degree to which the various collaborative tools supports the transmission of different information types is shown in Table 3. Information types that may be involved in a collaboration include:

- **Verbal (Speech) information**
- **Textual information**
- **Spatial/graphical information** - such as maps or drawings
- **Emotional information** – including fatigue, workload, competence, and anxiety which are often important in team collaboration activities
- **Photographic information**
- **Video information**

While face-to-face communications can include the transmission of all these information types, different tools are very poor or unable to support the transmission of certain information types well. For example video conferencing is poor for conveying spatial/graphical or photographic information or text (except in very small quantities held directly before the camera). Audio

conferencing, telephones and radios are similarly unable to transmit that type of visual information well and also cannot transmit video information. They are all quite good at transmitting verbal information, however, and can communicate some degree of emotional information (although generally not as well as face-to-face).

Tool Category	Information Types					
	Verbal	Textual	Spatial/Graphical	Emotional	Photographic	Video
Face-to-Face	Good	Good	Good	High	Good	Good
Video Conferencing	Good	None	Poor	Good	Poor	Good
Audio Conferencing	Good	None	None	Moderate	None	None
Telephone	Good	None	None	Moderate	None	None
Net Radio	Good	None	None	Moderate	None	None
Chat/Instant Messaging	None	Good	None	Poor	None	None
White Board	None	Moderate	Good	Poor	Good	None
File Transfer	None	Good	Good	None	Good	Moderate (Pre-recorded)
Program Sharing	None	Good (if program supports)	Good (if program supports)	Poor	Good (if program supports)	Moderate (Pre-recorded)
Email	None	Good	None	Poor	None	None
Groupware	None	Good	None	Poor	None	None
Bulletin Board	None	Good	None	Poor	None	None
Domain Specific Tools	Poor	Good (if program supports)	Good (if program supports)	Poor	Good (if program supports)	Good (if program supports)

Table 3. Taxonomy of Collaboration – Part 3

Conversely, other forms of collaboration, such as chat, white boards, file transfer, group ware, email and bulletin boards are very good at transmitting textual information, but very poor at communicating emotional information (despite the use of emoticons). Generally only domain specific tools, program sharing, file transfer or white boards are good for transferring spatial/graphical or photographic information.

**Collaborative Processes**

Finally, different collaborative tools are better suited to supporting different types of collaborative processes (Table 4). Different types of team collaboration that are typically seen include:

- **Planning**
- **Scheduling**

- **Tracking information**
- **Brainstorming**
- **Document creation**
- **Data gathering**
- **Data distribution**
- **Shared SA**

Tool Category	Processes							
	Planning	Scheduling	Tracking	Brainstorming	Document Creation	Data Gathering	Data Distribution	Shared SA
Face-to-Face	Good	Good	Moderate	Good	Moderate	Moderate	Moderate	Medium-High
Video Conferencing	Moderate	Decentralized Small N	Limited	Limited	Poor	Limited	Good	Medium-High
Audio Conferencing	Moderate	Decentralized Small N	Limited	Limited	Poor	Limited	Good	Medium-High
Telephone	Moderate	Good	Limited	Limited	Poor	Limited	Good	Medium-High
Net Radio	Moderate	Decentralized Small N	Limited	Limited	Poor	Limited	Good	Medium-High
Chat/Instant Messaging	Poor	Decentralized Small N	Limited	Poor	Poor	Limited	Moderate	Moderately-Low
White Board	Moderate	Decentralized Small to Medium N	Moderate	Limited	Moderate (non-text)	Limited	Moderate	Moderate
File Transfer	Poor	Centralized & Decentralized, Small to Medium N	Limited	Poor	Good	Moderate	Moderately Good	Moderate
Program Sharing	Moderate	Centralized & Decentralized, Small to Medium N	Moderate	??	??	Low	Low	Low
Email	Low	Moderate	Limited	Poor	Moderate	Low	Moderately Good	Moderately-Low
Groupware	Poor	Poor	None	Moderate	Moderate	Moderate	Low	Low
Bulletin Board	Poor	Poor	None	Moderate	Moderate	Moderate	Low	Low
Domain Specific Tools	High	High	High	Limited	Limited	High	High	High

Table 4. Taxonomy of Collaboration – Part 4

A great deal of difference is seen in the degree to which the different tool types support these different types of collaborative processes. Planning and scheduling tend to require a fair degree of interactivity, making many mediums poorer than face-to-face communication. Groupware, Bulletin boards, instant messaging and file transfer become particularly inefficient. Dedicated domain specific tools for these functions do quite well however, as they are structured to support the required information.

Brainstorming is also quite hampered in other than face-to-face communication, although some groupware and bulletin board systems can be used to support some types of brainstorming (such as the Adelphi method). While a number of tools can readily support data distribution, most are poor for supporting data gathering and tracking of information as it changes in a situation. Again, dedicated domain specific tools are much better for these types of tasks.

Building and maintaining shared SA typically involves more than just passing bits of data, it also involves sharing one's higher level comprehension of the

situation and projections of what is likely to happen, as well as information on one's task status necessary for efficient group task coordination. Due to a higher level of interactivity, video conferencing, audio conferencing, telephone and net radio can do a fair job of supporting these tasks, although in data heavy environments, only domain specific tools are able to supply the needed bandwidth for transferring the status of many entities and parameters.

## SUMMARY

The types of collaboration and communication required within team operations are quite varied. Building a system that can successfully support the collaborative activities present within command and control centers requires a careful analysis of the types of processes and conditions of collaboration needed in that environment. The Collaboration Taxonomy described above provides a first step tool for supporting design decisions in creating team-centric systems.

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## REFERENCES

- Computeruser (2002). <http://www.computeruser.com/resources/dictionary/definition.html>
- Grudin, J. (1999). CSCW and groupware: Their history and trajectory. In Y. Matsushita (Ed.), Designing communication and collaboration support system (pp. 1- 15). Gordon and Breach Science Publications: The Netherlands.
- Krasner, H., McInroy, J., & Walz, D. B. (1991). Groupware research and technology issues with application to software process management. IEEE Transactions on Systems, Man, and Cybernetics, 21(4), 704-712.
- Lantz, A. (2001). Meetings in a distributed group of experts: Comparing face-to-face, chat and collaborative virtual environments. Behavior and Information Technology, 20(2), 111-117.
- Nunamaker, J. F. (1997). Future research in group support systems: Needs, some questions and possible directions. International Journal of Human-Computer Studies, 47(3), 357-385.
- Searchnetworking (2002). <http://searchnetworking.techtarget.com>

Webopedia (2002). <http://webopedia.internet>